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Doing food security in practice: seeds, seed banking and preparations for the future

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Thesis submitted for the degree of Doctor of Philosophy,
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Abstract

This thesis is about the banking of the seeds of food plants. It considers the practices and politics of that banking in order to understand its contribution to future food security scenarios. The thesis expands upon existing literature to provide new analytical and empirical insights into the preservation of biological materials. It does so by examining how practices undertaken in seed bank settings function to make seeds into materials of use to food security practitioners; an outcome which is achieved by the incorporation of banked seed into the framework of plant genetic resources. The thesis also contributes to knowledge on food security, by examining the function of those plant genetic resources within the food security milieu. First, the temporalities engendered by seed banking are analysed. Here, it is argued that seed banking assists in enhancing food security by acting as a mechanism which folds the plant genetic resource materials of the past and future together through work undertaken in the present. Second, the material politics of plant genetic resource preservation in a food security setting are explored, and a case is made for a framework by which seed may be banked "well"; a framework which is hinged on seed materiality. Overall, the thesis makes two key claims. First, that food security should not be regarded as a state that can be reached, but rather as an ongoing process of strengthening the food system as a whole. Second, that seeds must be regarded as materials with agency in seed banking practice, agency which impacts upon the practice of seed banking itself and on the wider political setting of that practice.

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Table of contents

Abstract.....	1
Acknowledgements.....	2
Chapter 1: Introduction.....	9
The contribution of this thesis.....	10
The field of research.....	12
Seed banking.....	12
Food security.....	15
The point of convergence.....	16
The research of the field.....	21
Structure of the thesis.....	28
Chapter 2: Seed banking and food security.....	34
Introduction.....	34
Preserving biological materials.....	36
Studying “tribes of scientists”.....	37
Accumulating material and knowledge.....	39
Negotiating conflict, debate and politics.....	41
Non-plant biobanking.....	43
The rise of the food security agenda.....	47
The arrival of a concept.....	47
Global food security issues and the UK policy agenda.....	51
The irony of food security.....	58
Conserving seeds and genes.....	59
Seed banking's beginnings.....	61
Critical commentary on conventional seed banking.....	64

Kloppenburg's First the Seed.....	66
Past, Present, and Futures.....	70
Conclusion.....	74
Chapter 3: A materialist theoretical approach.....	76
Introduction.....	76
Materiality's return.....	79
Ceasing to be "less attentive".....	80
Materials, agency and actor-network approaches.....	85
Vital materiality.....	89
Relational materialities and multiple objects.....	91
Fluid objects and immutable mobiles.....	92
Practicing "multiple" materials.....	94
Politics.....	100
Latour and de Vries' exchange.....	101
Controversies.....	104
Marxism, actor-network approaches and geography.....	106
Ontological politics.....	108
Conclusion.....	113
Chapter 4: Research methods.....	115
Introduction.....	115
Actor-network approaches and research.....	117
Actor-networks and knowing.....	119
Fieldwork methodology.....	128
The research sites.....	131
Preliminary research activities.....	134
Undertaking ethnographic work.....	138
Undertaking interviews.....	148
Data analysis.....	154

Conclusion.....	160
Chapter 5: Seeds in practice.....	162
Introduction.....	162
Entering the plant genetic resources milieu.....	164
Receipt of new material.....	165
Generating new material.....	169
Plant genetic resources multiple.....	170
Regenerating stock.....	172
Stock management at the SSV.....	172
Stock regeneration at the JIC.....	174
Stock regeneration at the HSL.....	179
Coordination work in regeneration practice.....	184
Informing stock.....	185
Catalogues, files and datasets at the HSL.....	187
Material transfers from JIC.....	192
Coordination work in informational practice	197
Conclusion.....	198
Chapter 6: Seeds and the future.....	200
Introduction.....	200
Seed banking as a preparatory practice.....	202
An insufficient reservoir of plant genetic resources.....	203
What seed banking makes possible.....	206
Alternative sources of plant genetic diversity.....	211
Preparedness in practice.....	213
The routes to perpetuity.....	214
Two futures at play in regeneration.....	216
Doing seeds in the future.....	218
Experiments at the John Innes Centre.....	221

Trials at the Organic Research Centre.....	226
Conclusion.....	230
Chapter 7: Seeds politics.....	233
Introduction.....	233
Seeds as actors enacted.....	234
The materials of seed banking.....	235
Seeds, genes and plant genetic resources.....	237
Materialities disrupted.....	239
Commercialisation of heritage varieties.....	241
The effect of seed listing.....	242
Names doing work.....	244
Seeds doing names.....	248
Commercialisation and conservation.....	251
Doing seed banking well.....	255
Keeping options open.....	260
Assuring material mobility.....	262
Materiality of the politics of banking well.....	267
Conclusion.....	269
Chapter 8: Conclusion.....	272
The formulation of the research.....	272
Discussion of the findings.....	275
In what ways does seed banking act as a tool for doing food security in practice?.....	275
Making seeds into plant genetic resources.....	275
Seed banking and food security temporalities.....	279
Seeds as political materials.....	282
Contributions to the literature.....	286
New analytical and empirical insights into biological material banking...	286

Seed banking and food security.....	289
Researching food and agriculture within an actor-network framework...	290
Wider implications.....	292
Seed banking practice.....	292
Food security implications.....	293
Seed politics.....	296
Future directions.....	297
References cited.....	301
Appendix 1: Ethical research documentation.....	318
Appendix 2: Interview schedule details.....	325
Appendix 3: Images.....	328

Chapter 1: Introduction

In this thesis, I examine the contemporary practice of seed banking with reference to its role in improving the possibilities for future food security scenarios.

This project is the outcome of a confluence of interests which I was developing prior to beginning my PhD. Specifically, echoing debates elsewhere in the literature, I wished to undertake work which examined the notion of livingness framed by its being both a biological activity and a political practice (Rabinow, 2002; Rose, 2007). In particular, I was interested in the role that DNA played in this interface. Food and food security were, and indeed remain, live subjects of debate in both academic and policy fields, particularly in the wake of the conflicts around genetic modification which punctuated the 1990s and 2000s. As such, I regarded this as a lively field in which gaps in existing knowledge could be pertinently filled. Finally, following earlier research at postgraduate, I was attentive to the developments within the actor-network milieu, and was keen to employ them in a substantive piece of research of my own.

In this Introduction, I undertake three key tasks. First, I set out the terrain of the field of research, taking a historical perspective to explore the core empirical terms of the thesis, those of the banking of seeds of food producing plants and the notion of food security. Then, moving into the present, I demonstrate the timeliness of this thesis by looking at recent technical developments which show how seed banking and food security have come to intersect in a way generative of an illuminating and pertinent matter of

concern. Second, I move on to consider how I shall go about examining that matter of concern in the body of the thesis. I do so by introducing my theoretical framework, which is focussed on actor-network network approaches, and setting out my research questions. In the final section, I present the signposting for the thesis as a whole, outlining the content of each of the chapters to follow.

However, before undertaking these tasks, I use the following paragraphs to set out the central claims of this thesis and the originality of its contributions to knowledge.

The contribution of this thesis

The core aim of this thesis is to *provide new analytical and empirical insights into the practice of banking biological materials, specifically the seeds of food plants*. Within this aim, there are two strands. First, the thesis contributes to a small but extant literature in the social sciences on the collection, banking and storage of biological samples, often referred to in that literature as bioprospecting or biobanking. However, by being attentive specifically to food plant seeds, and by doing so within a framework of food security, *this thesis adds research material from a novel and unexamined angle* to that scholarly evidence base. Second, the thesis broadens the previously narrow range of social science knowledge about food plant seed banking specifically. Although seed banking has been practiced for several decades, academic attention from beyond the biological sciences has been directed almost exclusively at one specific sector of seed banking practice, that associated with the supply of seed of old fashioned varieties to hobbyist gardeners or those involved in counter-mainstream agricultural movements. This study is different. While attentive to this area, it also considers the role of seed banking in research and breeding for

mainstream agriculture, and as a tool for bringing about long term backups of food plant genetic material. By investigating seed banking in this way, this thesis avoids the artificial typologising of seed banks into classes or genres in the ways of such earlier work, and instead *generates understandings which encompass the broad scope of seed banking practice.*

This thesis adds nuance to the argument, voiced in policy and scientific literature, that seed banking may act as a useful tool in bringing about food security. It does so, by generating new understandings, rooted in social science thinking, of the mechanisms by which this may occur. The thesis claims that the practices by which seeds are integrated in, and managed by, different seed banking systems are integral to the way those systems are employed in seeking to engender food security. Furthermore, *the thesis intervenes in the broader food security debate, by arguing that scholars should examine food security as a set of practices, rather than as a state.* In other words, I make the claim that food security is not an outcome to be achieved or a state to be reached, but something in flux and always on the way to becoming. This is so because, in practice, food security must be responsive to the ever changing nature of the world at large. As the empirical material will demonstrate, seed banking plays a role in bringing about food security in practice by ensuring the availability of the genetic materials necessary for a plant breeding infrastructure able to respond dynamically to incremental and sudden changes in the conditions in which food crops are grown. Hence, *I attest that doing seed banking well is most effectively undertaken in ways which maintain as wide a possible sample of food plant genetic diversity and, in addition, ensures that this material is made available to the widest possible range of research and breeding organisations.*

Finally, this thesis adds weight to the claim that scholarly projects within the

food and agriculture milieu may be productively advanced by undertaking them within a theoretical framework centred on actor-network approaches.

Empirically and analytically, such a way of knowing is at the heart of this thesis. Consequently, this research has been guided by a desire to take seriously the role of materials, such as seeds, and practices, such as seed banking and seed research, in seeking to comprehend how seed banking acts as a tool for food security. In addition, *the thesis compounds the argument for the applicability of actor-network approaches in the formulation of politically efficacious research.* In setting out a schema of how to do seed banking well, intimated in the paragraph above, *the thesis presses the contention that the theory of ontological politics serves to enable useful political critique through close examination of the world in practice.*

Having set out the central claims of this thesis and the original contributions it will make to the scholarly knowledge base, in the next section I outline the field in which this research is located.

The field of research

In this section I explore the practices of seed banking and food security. I begin with a brief examination of the history of each, in order to offer a grounding upon which discussion in rest of the thesis will be based. I then demonstrate the timely nature of research which investigates the interface of these two areas, showing how recent developments in scientific practice have led to new connections emerging between them.

Seed banking

The beginnings of the formal banking of seed of food producing plants, in a way similar to its undertaking in the world today, is a story of some considerable

conflict. The Russian geneticist, Nikolai Vavilov (1887 – 1943), is widely recognised for introducing seed banking into contemporary scientific practice. Vavilov was interested in the science of genetics, or Mendelism as it was then termed (after the pioneering work on genetics by Gregor Mendel, see Henig, 2000). As such, he spent much of the decades of 1910 and 1920 travelling the world and assembling in Leningrad, now St. Petersburg, a vast collection of seeds representing numerous food plant varieties from those locations he visited. Within these collections were the raw materials which Vavilov employed in the development of his theory on plant centres of origin, a theory which remains relevant today (outlined in Nabhan, 2008).

Vavilov's infamy comes not only from his seed banking work and his development of the science of Mendelism, but from the consequences resulting from the wider setting of that work. His conviction of the accuracy of Mendelist theory led him to publicly counter the arguments, now known to be incorrect, of another Russian biologist, Trofim Lysenko. Lysenko argued that inheritance was not just genetic, and that characteristics acquired over an organism's lifetime could be passed on to their offspring. However, the dispute was political as well as scientific, as Lysenko's background and vocal public discourse had led him to become a favoured character of the Leninist regime. Consequently, in 1942, as punishment for his public disagreement with Lysenko, Vavilov was interred in a prison camp where he died a year later (Pringle, 2008). This was not the only dramatic event surrounding the emergence of contemporary seed banking. In the two years and four months duration of the Siege of Leningrad, which ended in January 1944, little food entered the city. The staff of Vavilov's seed bank, recognising the importance of the material it contained, guarded it from looters and themselves refused to eat any of the edible grains stored within it. As a result, surrounded by a possible food source, nine of those staff died of

starvation (Siebert, 2011).

Because of the dramatic nature of the story, Vavilov's seed collections have become a well known and well celebrated part of food plant seed banking history. While certainly at the scientific forefront, the facility itself nor the research undertaken within it was by no means unique. Indeed, the assembly of collections of plant material, whether associated with food production or otherwise, had been underway since the emergence of a culture of biological sampling and acquisition during the overseas explorations which were themselves the precursors to the colonial era (Parry, 2004, pp. 12–41; Whittle, 1997). Furthermore, underpinned by a necessity to increase productivity, by the early 1900s efforts were underway in Europe and North America to improve agricultural outcomes through experimentation and breeding. This was a practice which relied upon access to samples of biological materials in seed bank facilities (Kloppenburger, 1985; Murphy, 2007).

At the end of World War II, these efforts were redoubled with the work of the green revolution, the aim of which was to increase the productivity of agriculture by governments globally (for details on events in the UK, see Palladino, 1996). At this point, the plant breeding research agenda grew substantially in significance, with a great deal of work undertaken to develop elite, high output varieties of key crops. However, the resultant intensification of agriculture in the decades which followed saw more and more once common crop varieties being replaced by these elite lines. In disappearing from the agricultural landscape, there was a real risk of that crop diversity disappearing altogether. Thus, linked to a growing concern about biodiversity conservation more generally (for an introduction to this area, see Dyke, 2008), there came a push for seed banks to take on a conservation role (Fowler & Mooney, 1990) in

addition to their provision of plant materials for research. Today, there are over 1,400 food plant seed banks globally (Hicks, 2010), each of which stores material according to its own particular specialism, defined usually by geographic area or crop type.

Food security

Like seed banking, the concept of food security has been around for some decades. First discussed in 1974 at the World Food Conference, the "world food security system", as it was then termed, was centred on the assembly of reserves of grain which could be made available in years of low agricultural production in order to ensure global price stability and, hence, reduce incidences of famine in countries less able to bear the burden of such price rises (Shaw, 2007). Since then, food security has remained on national and international political agendas, wavering both in the extent to which it has been attended to and the methods proposed to bring about its improvement. By the early 2000s, with low food prices and rapid economic growth, in the policy arenas of Western Europe, North America and Australia, food security was little discussed.

In recent years, concerns about the long term stability of the world's food supply have reentered the political and scientific agenda. The impetus to address these concerns has been prompted by a period of substantial and sustained global price rises beginning in 2005 (Evans, 2008), coupled with recognition of vulnerabilities in the current food system, even in relatively affluent nations such as the UK, due to threats ranging from climate change to terrorism (Barling, Lang, & Sharpe, 2011; Defra, 2006). Much of this discussion has been incorporated within the umbrella term, food security. This a much contested and widely defined term (Maye & Kirwan, 2013; Smith, Pointing, &

Maxwell, 1992) which, broadly put, addresses whether groups of people from households to populations can assure their ability to feed themselves both now and in the future (Shaw, 2007; UN FAO, 2012, p. 57). The present stresses on food supplies, coupled with projected growth in the human population, has led to calls from a number of key organisations to significantly increase food production; the headline figure most widely called for being that of doubling output by 2050 (UN General Assembly, 2009). Although the figure itself is not universally agreed upon, for social, technical and environmental reasons (Soil Association, 2010; Tomlinson, 2011), those same critics would agree with the broad consensus that a business as usual approach to food production which disregards such concerns altogether is also untenable (Barling, Sharpe, & Lang, 2008).

The point of convergence

It is at this point which seed banking and food security have come to converge. Recent developments in the scientific thinking underpinning mainstream conventional agriculture have seen seed banking proposed as a core component of a broader toolkit for bringing about food security in a role which combines the research and conservation components of its practice (Royal Society, 2009). This is because *seed banks have come to be regarded as repositories of useful and novel traits currently found within old varieties (the conservation component) which have the potential to be bred into, and so enhance, the elite lines of food producing plants currently grown (the research component)*. In other words, it has been argued that within the vast seed collections already extant (which represent much of the genetic diversity of food crops from the recent past and across the world) are genetic traits at present unused which could help to secure food production (Royal Society, 2009). This could occur in ways such as incorporating traits which generate increased yield, providing

resistance to pests and pathogens, reducing reliance on agrochemical inputs, or helping to adapt plants to the changing climates of their growth environments

Indeed, the necessity of such a practice is supported by those working in the field. Although the current cohort of conventional food producing varieties is broad in number (in economically valuable grains like wheat, for example, varieties are bred to specifically reflect the conditions of the localities in which they are grown¹), the level of genetic differentiation between those varieties is low. Rather, most of these elite varieties (as these commercially important varieties are termed) incorporate the same key traits, such as dwarfing, as those first bred at the time of the green revolution (see Hedden, 2003). Furthermore, current techniques of plant breeding, which are based almost exclusively on conventional sexual reproduction of elite lines, have a very limited scope for bringing about significant genetic improvement. The incorporation of novel genetic material, perhaps from a variety stored in a seed bank, is not as simple as merely crossing a commercial elite line with that old variety. Having been developed over many generations, elite lines bear little resemblance even to their ancestors of just a few decades ago. The conventional sexual reproduction of an elite line and a seed bank variety would lead to offspring whose genetic make-up was fifty percent derived from the elite line parent, and fifty percent derived from the seed bank variety. In other words, the offspring would be plants of such significantly reduced quality that undertaking such a cross would be next to worthless .

As such, in recent years, scientists and breeders have been compelled to work with a model of plant breeding practice centred on the transfer of genes

1 The wheat varieties grown in East Anglia, for example, would likely not be the same as those grown in climatically different regions elsewhere in the UK, and would certainly not be the same as those grown in even in neighbouring European countries.

between one elite variety and another and, consequently, very little new genetic material is incorporated. As one of my interview participants, Dr. Simon Griffiths, a Project Leader at the Crop Genetics Department at the John Innes Centre, put it in an meeting with me:

And as time goes on, in the UK and globally, genetic gain gets harder and harder to achieve. Especially as it's a law of diminishing returns. If you just keep crossing the best with the best, you're shuffling combinations of genes but you're not getting anything new in there.

(Simon Griffiths, interview, 11 March 2011)

This is of great significance. Biological resistance to insect pests or plant pathogens is reducing in efficacy, as the pathogens evolve techniques to evade such resistance; with growing demand for food, it would be beneficial to increase output per unit area of land; there is a need to reduce reliance upon agrochemical and fertilizer inputs; and, finally, there is a risk of obsolescence in place-specific varieties due to changes in conditions in those places, often a result of climate change. The materials stored in seed banks have the potential to act as a resource from which novel traits may be obtained which could assist in any or all of those cases. In other words, gaining access to seed bank material could serve as a way of moving beyond that "law of diminishing returns".

Critically, new technical developments in basic plant science alongside cost reductions in existing techniques, are making access to, and utilisation of, the genetic material stored in gene banks technically possible for the first time (Gepts, 2006; Nordborg & Weigel, 2008). Another significant point is that *these techniques are based on making conventional sexual reproduction more*

effective, which is both cheaper and very much less conflict generating than genetic modification. Though even the most cutting edge of science is far from understanding the workings of the genome in its entirety (Barnes & Dupré, 2008), two significant developments in genomic technical knowledge, which I shall go on to explain, have come about in ways benefitting plant breeding by enabling access to seed bank material.

The first concerns inheritance. Since Mendel's experiments examining smooth and wrinkled peas, the role of individual genes in conferring simple quantitative traits² between one generation and the next has been well understood (Griffiths, Miller, Suzuki, Lewontin, & Gelbart, 2000). However, much inheritance, even for quantitative traits, is the result of more complex genetic activity involving groups of genes adjacent to one another on the genome. These groups of genes are termed Quantitative Trait Loci or QTL, and their presence has been known about for some time, having first been hypothesised in 1923 (Sax, 1923). Recently, however, knowledge about the workings of QTL has advanced significantly. It has become possible, as it is termed in plant research settings, to map QTL, or, in other words, to draw a direct association between the QTL on the genome and their expression in the plant itself.

The second significant development concerns the employment of those QTL in plant breeding. In conventional sexual reproduction, the offspring genome is a random mixture of components from each parent. In inheritance based on a single gene, such as wrinkled or smooth peas, each outcome has a fifty percent chance of occurring. With a QTL, the chance of its exact replication is much reduced. Rather than being a case of single gene being present or not present, the whole bundle of genes across the Locus, each of which has the potential for

2 Quantitative traits are traits whose presence or absence can be measured quantitatively.

differentiation, must be reproduced exactly. As such, transferring QTL from one generation to the next is significantly more challenging. Furthermore, in the past, the only way to ascertain whether a QTL had been effectively passed on would have been by growing out the plant, possibly to full maturity depending on the point in the growth cycle at which the trait in question could be identified with certainty. Thus, in seeking to transfer a QTL from one generation to the next, researchers were required to grow out a huge number of plants simply to identify the very small number in which that QTL had been passed on as desired. The difficulties that this would bring about were compounded by the fact that breeding useful QTL from seed bank varieties into elite lines requires crosses to be undertaken over a number of generations. In transferring the useful QTL, the initial cross of seed bank variety and conventional elite line will also transfer a great deal of deleterious genetic material. As such, the offspring needs to be crossed and recrossed back into the original elite line, a technique known as backcrossing, until a point is reached where the offspring generation has genetic characteristics more or less identical to the original elite line, but for inclusion of the sought after QTL.

Having to grow out vast numbers of plants in each generation solely to ensure the useful QTL is present makes such a process so costly and time consuming as to be untenable. However, a new technique called Marker Assisted Selection, or MAS, expedites proceedings considerably. MAS allows researchers to identify whether the QTL sought have been successfully transferred by that sexual reproduction without requiring the plant to be grown out and those QTL being checked for morphologically or experimentally. It does this by checking for molecular markers on the offspring generation's genome. As such, only the seeds which contain the useful QTL need to be grown out for backcrossing purposes and, consequently, the rate at which this kind of research and

breeding may occur is so significantly increased that it becomes a realistic prospect (full details of QTL mapping and MAS in crop improvement are outlined in Collard, Jahufer, Brouwer, & Pang, 2005, from which this explanation is adapted).

As such, for seed banking, the current moment is highly significant. *In the space of just a few years, seed banks have gone from being facilities of general conservation importance, to facilities conserving resources with a real potential to bring about significant change to the plants of mainstream agriculture.* The arguments for the conservation of old varieties considered to be obsolete, which were once made only by activists on the fringes of biological and agricultural research (such as Fowler & Mooney, 1990), have been vindicated. However, the significance of the current moment for seed banking is not solely located in mainstream agriculture. Some have called for a move away from intensive agriculture and towards alternative models based on, for example, organic farming techniques (Soil Association, 2009). Because they are not based on genetic modification, as noted above, these same advances in plant research and breeding techniques could just as well assist in the production of improved varieties compatible with the ethics of such alternative models. Furthermore, in some sectors, consumer demand is growing for traditional or heritage vegetable varieties (Briggs & Bardo, 2012). In short, there is some considerable interest in the materials stored in seed banks.

The research of the field

In its essence, seed banking is a very simple practice. Regarded solely from the point of view of its physical characteristics, a seed bank is a building within which there is a storage room cooled to a low temperature, usually below freezing and optimally at -18 degrees Celsius, and maintained at a low level of

relative humidity, in an ideal scenario, a level of about 3 to 5% (Engels & Visser, 2003). However, banking seed is not only a case of keeping materials cool and dry. *Seed banks operate in different ways, reflecting the particular interventions their parent organisation seeks to make in the world at large.* Seed banks may tailor their material to cater to the requirements of different user groups, or they may be more concerned with long term conservation of their stock rather than its being made available for immediate utilisation. As such, this thesis has been designed in a way which enables access to that diversity of intentions without taking on an unrealistically broad fieldwork agenda. This was done by investigating the seed banking practices at *three seed banks (the first two investigated as case studies and the third employed as a supporting study), each chosen to be emblematic of a strand of the broader diversity within the seed banking arena at large.*

The first case study was the seed bank at the John Innes Centre (hereafter, the JIC), a UK based seed bank which deals primarily with economically important staple grain crops within the mainstream agricultural research and plant science community. The second case study was at the Heritage Seed Library (hereafter, the HSL), also located in the UK, a seed bank which distributes non-commercial heritage vegetable varieties to members of the public and is affiliated with the gardening and agricultural campaigning organisation Garden Organic. The supporting study was at the Svalbard Seed Vault (hereafter, the SSV) which endeavours to build partnerships with all types of seed bank the world over, encouraging those seed banks to create back ups by duplicating their stock, and store those duplications in the long term storage facilities of their seed bank, which is located in the permafrost of the island of Svalbard, lying equidistant to the north coast of Norway and the North Pole.

In order to generate knowledge about these seed banks, *the research to be presented in this thesis will be grounded within the theoretical and methodological milieu of actor-network approaches*. Echoing the investigation underway here, these approaches were developed by scholars whose aim was to study the mechanisms of scientific practice using the tools of social science. In other words, their project was to understand the workings of “tribes of scientists” in the same way that anthropologists of the era were seeking to understand human societies in “exotic” locations (Latour & Woolgar, 1979, p. 17). Though the intention of this thesis, to understand how the role played by the practice of seed banking in food security, is rather more modest than that of those earlier science studies scholars (whose aim was no less than to generate new understandings of the workings of knowledge itself (Latour, 1987)), the thesis draws heavily from the outcomes emergent from this area of research in the following ways.

One key theoretical development from within the social studies of science was the elision of the conceptual boundary between nature and culture, or the human and the nonhuman. This was initially witnessed in the science laboratory, where it was observed that scientific knowledge was co-constructed by humans and nonhumans through practices such as conducting experiments and writing papers, rather than, as had previously been assumed, simply being a result of scientific work that discovered a series of pre-given certainties (Latour, 1987). However, the artificiality of the boundaries of nature and culture extends beyond the laboratory, indeed “[a]ll of culture and all of nature get churned up again every day”, whether in the news read from the daily paper or in the act of dispensing the contents of an aerosol can (Latour, 1993, p. 2). That same churning will be demonstrated in the two key areas of this thesis, seed banking and food security.

Related to that elision of the nature culture binary was a call to reconsider the agency of nonhumans. This plays out in the research process, where critique is levelled at research seeking to identify only "social explanations" (Latour, 2005a) for the phenomena investigated. This is because actor-network approaches, having concluded that the workings of the world are an outcome of the interactions of the human and nonhuman, seek to take seriously the role those nonhumans play in bringing about those workings. This was demonstrated in an early piece of actor-network based research which took place beyond the laboratory setting, examining the interface of science and economics in the decline in scallop populations in St. Brieuc Bay, western France (Callon, 1986). In this work, the author, Michael Callon, examined the way that a series of actors, both human and nonhuman, took on key roles in bringing the matter under investigation into being. Accordingly, work within actor-network approaches is centred on the investigation of all the actors whose interaction is generative of the event being researched (Latour, 1987). In so doing, rather than prioritising the work done by humans in a way typical of much work in the social sciences, according to actor-network approaches agency is to be regarded as symmetrical. In seeking to understand how seed banking and food security interact, the work of this thesis will be on the materials and practices associated with each. As such, to give a selection, it will take in the work of seeds, plant breeders, cold stores, seed bank staff, plants, datasets, and legislators in bringing about that interaction.

In investigating the world, Bruno Latour, one of the actor-network approach's key proponents, has called for researchers to "just look at controversies and tell what you see" (personal communication, in Venturini, 2010). By using the terminology of controversy, Latour elicits a particular line of thinking within

actor-network approaches more broadly, a line of thinking drawn upon but not directly employed in this thesis. Specifically, controversies occur in "moments of ontological disturbance" (Whatmore, 2009, p. 587), states of interruption in which previously taken for granted knowledge or events are thrown into disarray. What is more, as a consequence of this churning, events develop in which the politics of knowledge is played out not only in its discursive sense but in a way which also attends to "the devices, objects, substances and material settings in and through which publics are mobilized" (Marres & Lezaun, 2011, p. 490). In other words, controversies are moments in which democracy comes to encompass a set of very material framings (Latour & Weibel, 2005; Whatmore, 2009). Consequently, ethnographic research techniques have become a methodological staple for research in the actor-network milieu where scholars seek "to follow the actors" (Latour, 2005a, p. 12) as a controversy unfolds. Though not attentive to politics in quite this way, the research of this thesis follows that route by employing ethnography alongside interview and documentary analysis (Hammersley & Atkinson, 2007) in order to investigate the practices underway at the seed banks studied.

Like much of the best scholarly material, the aim of research in the actor-network milieu is not solely to understand the material investigated, *it is also to bring about interventions at points where this may be necessary*. In this thesis, I follow a version of politics attentive to the specific materials and practices of the cases in question, rather than drawing upon pre-existing political frameworks. This reflects the argument that "[e]ach new issue deserves its own protocol" (Latour, 2007, p. 818). The aim of my political intervention is to put forward an argument for the way by which seed banking might be practiced "well" (see van Dooren, 2009), and as such I draw upon the theory of ontological politics (Mol, 1999). The central work of ontological politics is to

consider what happens when events take place, not in terms of overarching power structures or centrally influential figures, but rather by examining events in the light of their being the outcome of a series of practices by human and nonhuman actors (such as Law & Mol, 2008b). Such an approach reflects the fact that what is currently considered to be political extends well beyond the scope of traditional formulations of representative, government-centred, democratic politics (de Vries, 2007).

The research, thus, seeks to access seed banking, food security and their intersection, in a way enabled by the theory of actor-network approaches. Central to this is a focus on materials and the way they are practiced, and it is for this reason that each subquestion is based on seeds and the practices with which they are affiliated.

The key question, around which the research is centred, was designed with these empirical and theoretical aims in mind:

In what ways does seed banking act as a tool for doing food security in practice?

This was divided into three subquestions.

1. How do seeds become the materials of a food security agenda?

As outlined above, work within actor-network approaches draws heavily upon the investigation of the actions of materials and practices. Consequently, in this question, I sought to employ such thinking by examining how the practices of seed banking act to make banked seeds into materials of utility in a food

security setting. The question was asked because an understanding of the concepts with which it would grapple were deemed a necessary underpinning for the material to follow. The question draws upon the assertion made by practitioners in all of the three seed banking organisations studied in this research, that the seeds banked are to be understood as what they term plant genetic resources. By examining the way seeds are practiced in seed banks (by which I mean, looking at the things done to them by seed bank staff in order that those seeds may enter the seed bank or continue to be stored therein) this question enabled me to interrogate the way those plant genetic resources for food security come into being.

2. What seed temporalities are engendered by seed banking and how do they function?

A core component of seed banking is necessarily an interaction with temporality, just as any practice of conservation is one of attempting to ensure that something of the present remains available in the future. Seed banking for food security is centred around, and engenders, an interesting set of temporal interactions or foldings as materials of the past undergo practices in the present in order that they may be employed in the future. The question was asked because I considered an understanding of the way those foldings operate to be crucial to the broader comprehension of the work of banked seed, or plant genetic resources, in the bringing about of food security. Again, the lessons of actor-network approaches directed my thinking, and I approached the question by attending to the materials and practices of those temporal interactions. Specifically, I examined the practices of storing materials in seed banks and, relatedly, the way those stored materials were employed in the work of research and breeding.

3. How do seeds function as politically engaged materials?

As has already been indicated in this Introduction, tensions, debates and opposing views exist within the broad arenas of seed banking and food security. With this already established, the aim of this question is to interrogate how such tensions play out specifically at the point of seed banking and food security's interaction. However, rather than seeking to investigate, for example, the way legislation affects seed banking practice, the question is phrased with a focus on seeds and materials. This is done in order to direct the response to one located in an ontological politics perspective rooted in actor-network thinking. As such, it is centred on the premise that seeds, as well as being efficacious as actors in a general sense, also play an active role in the formulation of the world politically.

The above questions structure the layout of the thesis, which is outlined in the following section.

Structure of the thesis

Chapters Two and Three position this thesis within the relevant literature by building upon the discussion of the conceptual and practical frameworks begun in this Introduction. The chapters engage critically with the literature of seed banking and food security, and of actor-network approaches and science studies. They do so in order to set out a framework by which to develop the research questions, locating the thesis' arguments around knowledge garnered from the current literature and, also, in the gaps isolated within that literature. Chapter 4 turns to the methodology of research, examining how the evidence which underpins this thesis was gathered and interpreted. Chapters 5, 6 and 7

present that material, locating it in the light of the research questions and the wider literature explored earlier on. Finally, Chapter 8 concludes the thesis, drawing its contribution together and indicating the possibilities for further research.

I now set out the work of each chapter in further detail.

Chapter 2: Seed banking and food security expands upon the references to seed banking and food security outlined in this Introduction, by drawing out in greater detail the debates underway in the literature of this area. It begins by locating the thesis in its field, examining in detail two key texts by Bronwyn Parry and Cori Hayden alongside scholarship on human tissue biobanking, which, because they are centred on the collection and banking of biological materials, are the pieces of contemporary scholarship most closely aligned with the work of this thesis. With reference to these texts, I argue that, while there is considerable knowledge about many aspects of the collection, banking and utilisation of biological material, attention to such practices in a specifically seed related food security milieu is missing from the literature.

I then move on to consider the concept of food security, examining its emergence and development. I show that it is, and has always been, a far from fixed concept, and some significant discussion surrounds its employment in the present day. Turning next to literature specifically addressing seeds and seed banking, I demonstrate that considerable technical scholarship exists in this area from researchers based in plant science disciplines. However, over the past decade, social science researchers have tended to confine themselves to its analysis from the perspective of the small scale, alternative seed banking organisations which deal solely in unusual varieties for amateur gardeners. That

said, I argue that comprehension of the setting at large can be obtained by drawing parallels with the biological material banking milieus of Parry and Hayden outlined in the opening of Chapter 2. Finally, I tie these strands together through an examination of literature on temporality. Arguing that undertaking seed banking for food security is a practice with particularly temporal consequences, I close the chapter by examining the workings of temporality according to recent discussions in the literature.

Chapter 3: Materiality and actor networks takes a more theoretical turn and, in so doing, draws out the connections between that theory and the wider research field to continue to situate this thesis within the relevant conceptual literature in which it is enmeshed. Chapter 3 is divided into three sections which build an argument for the adoption of an actor-network approach for the purposes of a research milieu attentive to the role of materials, as well as human intentionality, in the practices observed. Theorists central to this chapter include Bruno Latour, John Law and Annemarie Mol. I begin by outlining the return to interest in the material by social scientists, developing the argument into one in support of the version of materiality put forward by those in the actor-network field. I then move on to look at the interface of objects and practices, drawing particularly on the notion of multiplicity as a way to comprehend, first, how objects come into being as a result of their being practiced and, second, what happens when one object is practiced in several different ways. Finally, the chapter draws the two previous ideas together and turns to consider the role of politics within an actor-network framework, acknowledging the contributions of thinking around controversies but rejecting the calls for a weak version of the actor-network approach, and instead arguing in favour of a mode of thinking termed ontological politics.

In Chapter 4: Research methods the discussion turns to the way I went about gathering and interpreting the data for this thesis. I begin by considering the theory behind my research design, looking at the way those whose theoretical framework has been guided by actor-network approaches have typically undertaken fieldwork. Noting that such research requires a close attentiveness to day to day practices, I make a case for the employment of ethnographic methods supplemented by semi-structured interviews to construct the core seed bank studies and to draw together an understanding of the wider food security and plant research setting within which they are based. Within the chapter, I outline in detail the rationale for choosing to study the JIC, the HSL and the SSV, and set forth both the workings of the case study and supporting study approach and the reasons for limiting my research to these three. I also set out the way by which I employed additional semi-structured interviews and documentary analysis as a route to gain further knowledge on the utilisation of banked seed for food security element of the thesis. Finally, I outline the approach followed in interpreting the data and drawing out the themes to be presented in the remainder of the thesis.

Chapter 5: Seeds in practice is the first of my analytical chapters. Here, I examine the way that practices undertaken in the seed banking milieu transforms seeds into the plant genetic resources required for work in food security. I draw out several key seed banking practices which I argue to be critical to how this occurs. These are, first, the way seeds enter into and are incorporated within seed banking regimes; second, the practices of seed regeneration which are undertaken either to replaced stock levels depleted by use or stock degradation due to age; and third, the creation of an informational couch within which those banked seeds come to be known by seed bank practitioners and their user groups. I illustrate these practices with extensive

reference to the ethnographic material obtained during my research phase and conclude there to be considerable parallels between the making of plant genetic resources at each of my core seed bank studies. The understandings of how seeds are made into plant genetic resources serves to underpin the arguments about their utilisation made in the chapters which follow.

In my second analytical chapter, Chapter 6: Seeds and the future, I build upon the development of the plant genetic resources concept by considering specifically the role of the seed bank setting in its operation. I argue that the function of plant genetic resources in a food security milieu is the result of the successful bringing about of a series of temporal interactions; temporal interactions which are engendered by the material practice of seed banking. The chapter claims that the conservation and utilisation of plant genetic resources is a tool predicated upon the folding together of past and future, achieved by actions, specifically the desiccation of seeds and their storing at low temperatures, underway in the present. In other words, seed banks store seeds of the past, which, through practices of plant genetic resource-making in the present, are readied for employment in the bringing about of future food security scenarios. Alternately, this may be conceptualised as the materials of one time being folded into practices undertaken in another. However, complexity is generated in this scenario because of the unknown and unknowable nature of the future. Banking seed is argued to be a practice that has been undertaken, not because it is thought certain to bring about food security, but rather because it is considered to be a necessary preparatory act which has the possibility of being of utility. To illustrate my argument, I close the chapter with an examination of two very different research projects in which banked seed were at the centre.

Having looked at the way seeds are made into plant genetic resources and the way that plant genetic resources operate in a temporal fashion, the final analytical chapter, Chapter 7: Seed politics, addresses the practice plant genetic resource conservation through a political lens. The argument of the chapter is cumulative. It calls, first, for seeds to be recognised as actors which make a difference politically by demonstrating them to be agentic materials in the formation of emergence of overall seed banking practice. I build on the recognition of this agency to turn, secondly, to consider seeds within a defined political event underway during the data collection period, that being the change of the law governing the distribution of heritage seeds. In so doing, I argue that the agency of seed materiality, as well as the legislation itself, will have a role to play in determining the longer term consequences of this legislative change. Finally, drawing upon the conclusions from the previous two sections, coupled with the arguments of Chapters 5 and 6, I make a series of arguments about what good seed banking might look like, or, in other words, how to do seed banking well. I contend that the interface of biological imperatives and human use requirements require a version of seed banking in which options are kept open, by the continued maintenance of a wide diversity of genetic material, and materials are kept mobile, made available to all in the plant research and breeding community.

In Chapter 8: Conclusion, I draw together my analysis of the practices which go into shaping the way seed banking acts as a tool for doing food security, as they are set out in the three chapters which precede it. In addition, I comment on the way the food security concept has developed since the inception and research of this thesis, and put forward suggestions of potential future research in the light of these developments.

Chapter 2: Seed banking and food security

Introduction

This chapter, which is divided into four sections, begins to frame the arguments through which I will respond to the central research question of the thesis, "In what ways does seed banking act as a tool for doing food security in practice?", by exploring the literature of, and surrounding, its two central concerns, seed banking and food security.

In the first part of this chapter, I locate this project directly within its scholarly milieu through the examination of two recent and influential monograph length studies on the acquisition, preservation and utilisation of plant biological materials in technoscientific settings. These texts are Bronwyn Parry's *Trading the Genome* (2004) and Cori Hayden's *When Nature Goes Public* (2003). Also in this section, I broaden the scope of analysis beyond plants by considering the developments in the field of human tissue biobanking. Although the specific practices attended to in these texts are, in many ways, quite different to seed banking, they set the scene for the thesis at large both in terms of the themes their respective authors draw out, with which there are some significant parallels to those of this thesis, and in the ways those authors achieve this, both methodologically and theoretically.

Having identified and examined the core works most proximate to this thesis, the remainder of the chapter is spent developing the themes pertinent to my own research, the analysis of which serves to differentiate this study from those of Parry or Hayden. In the second section of the chapter, I turn to an

examination of the emergence and development of the notion of food security up to the present day. I do this because an understanding of the food security concept is a necessary foundation for the consideration of contemporary food plant seed banking practice. As argued in Chapter 1, the undertaking of contemporary seed banking is commonly framed as a tool to assist in the bringing about of food security. Beginning with an account of the emergence of the food security concept in the 1970s, this section unpicks the developments which led to it becoming a defining part of today's food policy arena. Far from being stable, the past four decades have seen the notion of food security take in and abandon a wide range of meanings and practices. As a consequence, I demonstrate how the term may be regarded as being in tension.

The food security foundations now laid, the chapter's third section examines seed banking practice itself. It begins by considering the biological activity which engenders genetic diversity. It then explores the way that genetic diversity has been conserved using seeds, and, later, how the terminology of plant genetic resources came to be central to that conservation. The preservation of these resources today is argued by many to be an imperative in the light of the emerging food security agenda, discussed in the previous section. However, I argue, this is no simple practice. First, whether termed seed banking or plant genetic resource preservation, the practice itself is not a new one and, resultantly, the contemporary plant genetic resource preservation regimes are contingent outcomes of the many decades of practice which precede them. Second, while the technicalities of plant genetic resource preservation are fixed, the aims and principles of each individual seed bank may be very different. As such, I explore literature examining the various ways that plant genetic resources are conserved. Notably, I find there to be two clearly defined strands of scholarship, one centred on informal conservation

techniques of heritage type seeds and the other studying organisations working in the scientific establishment. I examine the former before showing that, while there is a paucity of scholarship directly addressing that latter, pertinent similarities do exist with the practices of biobanking. Hence, I draw parallels with the writing of Parry and Hayden previously examined in the first section of this chapter.

Seed banking is a practice of conserving materials of the past, whereas food security is a concept which aims to engender outcomes in the future. Central to each, therefore, is a relationship with time. As such, I close this chapter by drawing these ideas together by their discussion in the light of literature around temporality and, in so doing, put forward a framework through which I shall go on to respond to the second of my three research sub-questions, "What kinds of temporalities are engendered by seed banking and how do they function?". Instead of regarding time in a linear fashion, where events simply come about one after another, thinking on temporality encourages attentiveness to the foldings of the past, present and future into one another as events occur in practice. In this way, the foundations are laid for the later examination of the way by which seed banking contributes to the bringing about of food security, and the political and ethical consequences of its doing so.

Preserving biological materials

In this first section, I examine two monographs which make up the central scholarly milieu of this thesis, each of which being an exploration of the practices of acquisition, preservation and utilisation of plant biological materials. I conclude the section by considering those practices in their wider setting by examining the parallels between the key ideas raised in those two monographs and practices in the wider biobanking sector, focussing specifically on human

tissue biobanking. I locate this examination at this point in the thesis in order to set the scene for the research I shall do, and expose the gaps in the literature which this thesis serves to fill.

Studying "tribes of scientists"

In their work, both Parry and Hayden endeavour to do what Bruno Latour and Steve Woolgar call for in the passage cited below, and which I similarly endeavour to do in this thesis; to penetrate and learn about "tribes of scientists" (Latour & Woolgar, 1979, p. 17):

Since the turn of the century, scores of men and women have penetrated deep forests, lived in hostile climates, and weathered hostility, boredom, and disease in order to gather the remnants of so-called primitive societies. By contrast to the frequency of these anthropological excursions, relatively few attempts have been made to penetrate the intimacy of life among tribes which are much nearer at hand. This is perhaps surprising in view of the reception and importance attached to their product in modern civilised societies: we refer, of course, to tribes of scientists and to their production of science. *Whereas we now have fairly detailed knowledge of the myths and circumcision rituals of exotic tribes, we remain relatively ignorant of the details of equivalent activity among tribes of scientists, whose work is commonly heralded as having startling or, at least, extremely significant effects on our civilisation.*

(Latour & Woolgar, 1979, p. 17 emphasis added)

In general, as Latour and Woolgar go on to argue, attention to these tribes is necessary because of the significant role their practices play in shaping the contours of the civilisation in which we live. Specifically, the investigations cited

here examine these contours in the framework of newly emerging ways of knowing, managing and utilising biological material which have the potential to profoundly alter the course of medical and agricultural developments, as well as being of significant local and geopolitical consequence. Each text is attentive to a subject which had become, at the time of their writing, a matter of some debate. The texts examine the subject of bioprospecting, a shorthand term for the transfer and accumulation of biological materials from countries, usually in the developing world, in order that those materials may be investigated for their utility to the development of new pharmaceutical products, or otherwise biologically active compounds such as pesticides, by companies based in wealthy regions.

That said, each text follows a different approach in doing so. Parry is interested in the way biological material moves from place to place. In her monograph, *Trading the Genome* (Parry, 2004), she accounts for the way biological material circulates in the world of capitalist accumulation and exchange. Parry's approach is reflective. By drawing on interviews undertaken with elite figures in the sector (Parry, 1998), she shows how technological advances have facilitated this commercial exchange of biological material by transforming it, reducing it from its original form into cell samples, genetic information or other raw data which act as, in her terms, stand ins or "proxies" for that original material. It is, she demonstrates, these proxies which are exchanged commercially and with which, eventually, scientists then work. Hayden's monograph, *When Nature Goes Public* (2003), is also attentive to the commercialisation of biological material, but in different and less spatially oriented ways. Her research, which is based on detailed ethnographic studies in Mexico and the United States, draws out the practices by which biological materials become implicated into the commercial realm. By associating herself with a team of researchers,

Hayden produces a comprehensive account of the practices of bioprospecting. In the following review, I consider their discussion of two key areas, first, the collection of materials and, second, the politics of those collections. I do this because they are significant issues which crosscut each text and which echo concepts which later become central to this thesis.

Accumulating material and knowledge

First, I consider the accumulation of material. As Parry puts it, "although bioprospecting is often characterized as an activity devoted to the *exploration* of biodiversity, I would argue that it is, fundamentally, about the practice of *collecting*" (Parry, 2004, p. 11 emphasis in original). In other words, Parry's assertion is that it is the accumulation of material, moving it from one place to another, rather than efforts to bring about its immediate commercialisation in ways that might be expected in conventional resource prospecting for energy or minerals, which defines the act of bioprospecting. Each text describes the acts of the physical collection of material, Parry doing so in a way which draws out the similarities between today's sample collection and that of the gathering of specimens for the herbariums, zoos and museums of the past, Hayden by observing the practices of researchers whose work takes place in the marketplaces and roadsides of Southern Mexico. Each also reflects upon the places in which collected material is moved to and stored. However, Parry's central point, reflecting the one upon which my analysis in Chapter 5 is rooted, is that the act of accumulating materials is not, on its own, enough: "Simply holding a collection of biological material affords the collector no particular scientific or commercial advantage unless that material can be rendered and acted upon in novel ways," (Parry, 2004, p. 150). As each author goes on to discuss, transforming that material such that it may be "rendered and acted upon" (Parry, 2004, p. 150) requires that material holdings are "enriched" (in

the terminology later coined by Barry, 2005) by the accumulation, during its collection or afterwards, of knowledge about that material. In short, in the bioprospecting milieu (and, too, the seed banking milieu), the collection of material and the collection of information about that material are practices so closely entwined they should be understood as simultaneous.

Through her ethnographic work, Hayden considers two quite distinct sources from which information is gathered. She examines the information accrued by the biologists whose work she tracks as they purchase samples from market stalls. This information is garnered both directly from vendors and from noting that which can be inferred from the way materials are displayed and the signage that goes with them (Hayden, 2003, pp. 125–126). It is in this way that “markets ... become points of departure for more detailed studies of medicinal plant uses, chemical properties, and plants' biological and commercial distribution ranges” (Hayden, 2003, p. 126). Later, a second and somewhat contrasting mode of information gathering is undertaken. A sample of the material is introduced into a test tube containing brine shrimps, aquatic crustaceans a few millimetres in size, and the death rate of these organisms following their exposure to the sample is measured. That death rate is taken as an indication of the sample's potency and, as a consequence, its suitability for further investigation, and its potential utility in commercial milieu (Hayden, 2003, pp. 198–204).

Parry's attention to the information within which biological samples are couched is centred on the development of her broader thesis that such information may act as a replacement, or “proxy,” for the material itself. The creation of proxies is crucial, for it is these which facilitate the movement of material from one place to another. The act of generating a proxy of a piece of biological matter is

an act of divesting of "the existing physical structure or body of the organism ... in order to privilege and more effectively mobilize some other 'key' or 'essential' components of it" (Parry, 2004, p. 165). In other words, in creating a proxy one sheds material unnecessary or excessive for the functioning of the sample in a commercial or research milieu. The creation of proxies of biological materials is undertaken, Parry argues, because, in their form either as information or as small samples of specific cells, these proxies are easier to store and move from place to place, and, further, may be more easily worked upon and manipulated in experimental milieus (2004, p. 72). Although the majority of her work is centred on the accumulation of biological material in cell sample form or as digitised genetic code, she does briefly reflect on the use of seeds as "useful proxies for whole plants" (Parry, 2004, p. 70) in historical collection practices.

Negotiating conflict, debate and politics

As noted above, the practice of bioprospecting is one which has elicited, and which continues to elicit, some debate. In being a subject of conflict, by which I mean, in being exposed to a range of competing requirements and expectations by different stakeholders, the accumulation and banking of material by bioprospecting becomes a matter of politics. My intention here is to show that, although there are significant differences in the parameters of Hayden's and Parry's bioprospecting and the seed banking for food security which I examine, similar themes around material movements and their governing legislation are reflected in each. Specifically, those themes are ones to do with the transfer of materials from one site to another, and the engagements with regulation that underpin those transfers and the eventual use of that material.

In both Hayden's and Parry's studies, much of the politics comes about as a consequence of the international transfer of that biological material; specifically,

whereby samples are moved from an area of comparatively low income, specifically Mexico in Hayden's case, to one of comparative wealth, the United States. This is compounded by the fact that those samples are sought with a view to their being utilised in research and development geared toward the making what are eventually intended to be profit generating products. Although detailed rehearsal of the specifics of each case is beyond the necessary scope of this chapter, it is noteworthy that each author does undertake a comprehensive review of the various national and international regulatory regimes by which the collection, transfer and trade of biological materials are governed, as well as the considering the bodies which underpin them. As both authors show, such regulatory frameworks are crucial in outlining what is permissible in the practice of collection, and the obligations, both financial and in terms of the rights of utilisation, then incumbent upon the collector with regard to the local or national community from which the material was collected (on bioprospecting's governance see Hayden, 2003 Chapter 3; on associated compensatory agreements see Parry, 2004 Chapter 6). However, as I shall also examine in Chapter 7 of this thesis, the outcomes of even the clearest of regulation are complicated when they are brought into being through practice. As such, their outcomes are shaped by that practice, which may too lead to unexpected consequences, as is illustrated by the following vignette from Hayden's study which discusses the complexities of abiding by compensatory regulation.

For the sourcing of material of comparatively probable utility, the market stall is considered to be a more reliable location than a roadside (Hayden, 2003, p. 178). This is due to the nature of their stock and the greater availability of information as described above. However, as a space, it throws up questions surrounding whether vendors should personally be paid royalties for materials collected from their stalls should compounds from those samples go on to prove

valuable (many argue they should not, Hayden, 2003, p. 134). However, the collection of ostensibly public material from roadside verges is similarly problematic. As Hayden observes, in the particular environment in which she was working, "questions of jurisdiction are far from straightforward" (2003, p. 178). For example, attaining written permission to work from the municipal authorities might mean little when many of the nearby indigenous people do not feel represented by such authorities. The consequences engendered by the application of the legal protocol of compensation may be unexpected. As Hayden notes, biological materials, because of the potential for wealth they generate, rather than being regarded as either a globally owned resource or the stuff of the locality in which they were collected, have come to be articulated through, and simultaneously, assist in the further articulation of, the Mexican nation state (see also Hayden, 1998, 2003, pp. 108–122).

Non-plant biobanking

I close this section by reflecting on how discussions similar to those cited above occur elsewhere in the biobanking milieu. Non-plant material, by which I mean specimens of human, animal or microbiological tissues, are also incorporated into regimes of collection, banking and utilisation. Although the material itself, as well as the practices of its collection and storage, differ quite considerably from plant material biobanking, there are some significant parallels in the kinds of problematics the practices raise. In this subsection, focussing on human tissue biobanking, I examine those parallels with reference to recent debates in associated sections of the literature.

Just as in the banking of plant materials discussed by Parry and Hayden, the accumulation of samples of human material is only the first in a series of steps which lead to the incorporation of that material within a biobanking milieu. As

with plant matter, the accrual of knowledge about that which is collected is essential. Indeed, as Richard Tutton and Oonagh Corrigan argue, a genetic database or biobank involves "the collection, storage and use of physical tissue (usually blood, but by no means exclusively so), [as well as] genotype and other biological information derived from that tissue, and a variety of personal data from populations of various sizes" (Tutton & Corrigan, 2013, p. 3).

However, an additional knowledge framework is required for the incorporation of biological specimens of human origin into banking regimes. Because the collection of a samples often requires a physical intervention, such as taking blood, and, what is more, in order that research is undertaken following accepted ethical norms, those collecting the samples are usually required to gain informed consent from those whose samples are banked. In other words, to gain the materials for human tissue biobanking, information may be sought from donors to contextualise the sample they give, but they too must be informed about the uses to which their samples may be put.

This requirement for informed consent raises a further problematic. Consent for the collection of plant materials, if it is sought at all, is sought from groups of peoples incorporated within the, often somewhat hazy, notion of "the community" in ways called for by the Convention on Biological Diversity (Andanda, Schroeder, Chaturvedi, Mengesha, & Hodges, 2013, pp. 38–39; on the problems of the notion of community, see Reardon, 2005, in Hayden, 2007, p. 745). By contrast, the consent required for the collection and utilisation of human tissues must come from every individual whose material is collected. As with plant materials, the complexities and contestations that arise when seeking consent is played out in practice by biobanking and research organisations has been of interest to scholarly research. For example, while informed consent should routinely be sought, evidence suggests that those

giving samples might not always be fully aware of what they are consenting to. This scenario has become increasingly common with the shift in research agendas away from the specific, such as work on a specific genetic disease which the donor either suffers from or is closely related to a sufferer, and toward general population-wide studies (Busby, 2013, p. 39). This is illustrated in the case of UK blood donors, where those offering blood were often unaware of the fact that they had agreed that their donation might be used in research rather than being transplanted into another human (Busby, 2013). Likewise, pharmaceuticals companies undertaking may well incorporate a clause in to their consent procedures which allows them to retain samples from one study to use in later associated studies (Corrigan, 2013).

Finally, just as Parry and Hayden explored in the case of plant tissues, there is some debate as to whether and how profits derived from the commercial exploitation of banked biological materials should be shared with the donors of those materials. As Hayden argues, in both plant and human tissue biobanking, there have been moves away from altruism or the notion that such biological material is to be considered a common resource and towards benefit sharing arrangements. This has occurred as public awareness of how tissue sample donation "may well enable quite a lot of profit for those on the receiving end of these transactions" (Hayden, 2007, p. 730) has grown. For Hayden, the push towards benefit sharing opens up a series of political questions hinged around the fact that as people are inevitably included in human tissue research, either as tissue donors or as users of the products derived from that tissue donation, people need to be included "well" (Hayden, 2007, p. 733). Though the term is problematic, as observed above, Hayden argues that benefit sharing is best articulated collectively through communities. Indeed,

[t]he question of how to recalibrate takings and givings in the domain of bioscience has generated an intriguing array of imagined collectives: government tribunals convened to determine and administer liability rules, patient advocacy groups formed to effect a kind of 'collective bargaining' in the research process, charitable trusts grounded on fiduciary relations.

(Hayden, 2007, p. 751)

That said, Hayden is sceptical of the ability of existing vocabularies of publicness to accurately reflect "the heterogeneous forms of collective, political sociality that are required and requested in efforts to rewrite the social contract that is biomedical research" (Hayden, 2007, p. 753). This is because, rather than seeing benefit sharing as the solution to the political questions raised by biobanking and biomedical research, she would prefer to regard it as a vector by which to "open up a host of unanswered political questions about contemporary processes in which forms of political representation and modes of allocating resources are very much a site of struggle" (Hayden, 2007, p. 753).

In examining the banking of biological materials for future use, both Parry and Hayden's monographs and the consideration of the wider biobanking milieu have a significant role to play in the placing of my research in its wider academic setting. Furthermore, while the two key themes drawn from Parry and Hayden's work, reflected in my broader literature survey, and outlined in the section above, reflect matters to be addressed in this thesis, the precise boundaries of my research are rather different. Specifically, my interest is in how banking practice is undertaken, not in the assembly of samples for speculative scientific research but in scenarios centred on the banking of biological materials, and specifically seeds, in a food-centred setting. As such,

in the remainder of this chapter, I examine literature specifically related to this. I begin by exploring one of the study's central concepts crucial to the understanding of seed banking, that of food security.

The rise of the food security agenda

In this section, the contours of the food security agenda are outlined, charting it from its emergence to the nuances and contestations playing out in its use in the present.

The arrival of a concept

This statement, drawn from a recent glossary definition of food security in a report by the UN FAO, is a longstanding definition frequently repeated in writing on the subject:

Food security. A situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

(UN FAO, 2012, p. 57)

Food security has become a term the citing of which is supposed to make common sense the pronouncements which it precedes. But the meaning of the term is by no means settled. In the early 1990s, a survey of its use revealed over two hundred different definitions (Smith et al., 1992), a number which, some two decades later, can only have grown (Jarosz, 2011) (for further discussion see Cloke, 2013; Mooney & Hunt, 2010; Pinstруп-Andersen, 2009). As such, rather than seeing food security as a stable concept, it is more helpful to conceive of its employment as echoing the workings of a "sociology of

translation" (Callon, 1986). By this, I mean that I follow Michael Callon's terminology to observe that the emergence of the food security idea, and the continued but shifting terms of its use, can best be regarded as a tussle for *interessement* between actors, experts, and obligatory passage points. Food security has already long encompassed "a cornucopia of ideas" (Maxwell, 1996, p. 155). However, that multiplicity may be problematic. As Damian Maye and James Kirwan recently argued, agreement on the meaning beneath the idea of food security should best be understood as "fractured". Elaborating, they contend that "while there is a broad consensus that food security is a vital future challenge, there are significant fault-lines in terms of how to re-structure and develop socio-technical innovations to make agri-food systems more resilient" (Maye & Kirwan, 2013, p. 2).

Food security as a piece of terminology first came about as words within an expression of far broader scope, as analysis of the narrative presented in John Shaw's (2007) text *World Food Security: A History Since 1945* reveals. The food crisis of the early 1970s led to a meeting of delegates under the banner of the World Food Conference, held in Rome in 1974. The crisis was then understood to be a consequence of severe shortages of global food stocks, and as such there were calls for the establishment of a "*world food security system* which would ensure adequate availability of, and reasonable prices for, food at all times, irrespective of periodic fluctuations and vagaries of weather and free of political and economic pressures" (United Nations Universal Declaration on the Eradication of Hunger and Malnutrition, cited in Shaw, 2007, p. 140 emphasis added). The resultant "world food security system" was one of increased global grain reserves available to be called upon at times of food shortage, particularly by the developing world. Though this seemed a sensible response, in practice the establishment of these reserves did little to reduce the

problem for which they had been founded.

Research by Amartya Sen, particularly his essay *Poverty and Famines* (Sen, 1981), is widely credited for moving the terms of the debate (see, for example, González, 2010; Shaw, 2007). For Sen, hunger, or in other words, an absence of food security, was rarely a consequence of absolute food shortage, particularly not when total food availability was calculated globally, but rather it was a result of a lack of, what he termed, entitlement to food (the entitlement thesis was one he first introduced in Sen, 1976). Famine, he argued, comes about when for economic or social reasons individuals or groups of people are unable to access the food they need to survive. A 1983 rewriting of the UN documentation in the context of these theoretical advances saw the “world food security system” recast as simply “world food security”. The definition written then is the one upon which today's is based. It read “[t]he ultimate objective of world food security should be to ensure that all people at all times have both physical and economic access to the basic food they need” (Report of the Conference of FAO, November 1983, cited in Shaw, 2007, pp. 241–242). The removal of the word “system” is highly significant. It represents a move from food security as a state that may be arrived at through the completion of various systematic actions, such as assembling grain reserves to enable their use in times of need, to food security as a process, something which is ongoing and requiring continuous adjustment. Later incarnations saw the word “world” dropped too, as the focus on individuals represented in that 1983 revision became further anchored in the concept, and spatial delineation, such as between nation states, became less clear in either theory or practice.

The past pliability of the food security concept is indicative of its continued pliability in the present, which shows itself in two important ways. First, there is

an increasing amount of critical reflection on the solutions proposed in response to food security frameworks. Isobel Tomlinson's (2011) paper is an excellent exemplar of the wider debate. In it, she suggests that the generally accepted necessity to double food production by 2050 in order to feed a projected world population of nine billion requires questioning. The figure is, she believes, based on calculations about food output, production processes, and consumption, which are of questionable accuracy. Moreover, she argues that such thinking does not address the pre-existing structural faults in the food system which she posits as the central causes of malnutrition (see also Soil Association, 2010). Many of these faults are a consequence of the way the market drives the food system's function which, amongst other things, inhibits access and results in excessive environmental impact (Lawrence, Lyons, & Wallington, 2011; see also Nally, 2011).

Second, the term's targets, both empirical and geographical, have begun to broaden. In the main, much research does retain its longstanding interest in the developing world, as a survey of publications in the journal *Food Security* revealed. Of the eighty original research articles, published in seventeen³ of the nineteen issues of the journal in the time between its establishment and the time of writing (April 2013), which included a country or region in their title, in only two was the research centred on a high income location⁴. However, interest has begun to develop in research which broadens that empirical and

3 The two issues excluded were special issues in which all papers were required to address a specific region. Although in both cases these were developing world regions too, they have been excluded from these figures because of their status as special issues.

4 One, on the regulatory mechanisms for plant diseases and food security investigated through British potato production (Dehnen-Schmutz, MacLeod, Reed, & Mills, 2010); and, the other, on the threat to European agriculture and forestry from agroterrorism, (Suffert, Latxague, & Sache, 2009).

geographical purview. One recent example of this is a study of food insecurity as a consequence of economic marginalisation in a comparatively wealthy region. According to Mark Nord and his colleagues, in 2009 around 17.4 million US households, or 14.7 percent of the overall total, were considered food insecure (Nord, Coleman-Jensen, Andrews, & Carlson, 2010). This meant that at times during the preceding year and due to lack of financial resources those households were unable to provide adequate food for all their members. But for most wealthier states, the conceptual framing by Nord et al. is the exception rather than the rule. In such states the landscape and lexicon of the political arena has tended to be such that even when it is recognised that there is a problem of nutrition for some members of the community, such as the rapid growth in numbers of food bank users in the UK over recent years (Tussell Trust, 2012), it is invariably not framed as a food security problem *per se*. That said, as I shall demonstrate through the case of Britain in the section which follows, increasingly governments, think tanks and NGOs in the world's more wealthy regions are turning their attention to something they have been calling food security. However, as I shall also show, the contours of that version of food security have shifted once again.

Global food security issues and the UK policy agenda

Over the past decade food security has come to be an issue of some considerable importance to the UK policy agenda (Barling et al., 2011). In part, this has been influenced by a series of shifts which have occurred globally in the food system, pushing up prices and reducing the reliability of supplies (Maye & Kirwan, 2013). It was concerns about the ratio of domestic food production to overall consumption, known as the self-sufficiency ratio, and about disruption of the food supply as a consequence of threats ranging from climate change to terrorism which first enlivened thinking on food security in

the UK (Defra, 2006). The Department for the Environment, Food and Rural Affairs (Defra) took up the issues in a document produced in 2006 called *Food Security and the UK: An Evidence and Analysis Paper*. At this stage, policy makers appeared sceptical as to the extent to which food security should be regarded as being a pertinent UK issue at all, as this quotation from the paper indicates:

Poverty and subsistence agriculture are root causes of national food insecurity. National food security is vastly more pressing for developing countries than for the rich countries of western Europe. As a rich country, open to trade, the UK is well placed to access sufficient foodstuffs through a well-functioning world market.

(Defra, 2006, p. iii)

The government of the time was slow to keep up with wider thinking on food security (Barling et al., 2008). Publications by the then opposition Conservative Party (Quality of Life Policy Group, 2007), and from the non-governmental international affairs think tank Chatham House (Chatham House Food Supply Project, 2008), were where, David Barling and colleagues argued, the cutting edge of food security discussion was taking place (Barling et al., 2008). It was not until 2008, with the publication of the paper *Ensuring the UK's Food Security in a Changing World* (Defra, 2008), that the government took on the discussion in any serious way. This was a time at which concerns around food security were gaining a place on agendas worldwide as a consequence of a steep rise prices which, unusually, "applie[d] to almost all major food and feed commodities, rather than just a few of them" (Evans, 2008, p. 2). These were catastrophic increases for many of the world's poor, triggering unrest in Africa, Asia, South America and the Caribbean (Rosin, Campbell, & Stock, 2012). UK

consumers felt the difference too. In June 2008, overall inflation was 3.8% while food price inflation was 9.7% (Defra, 2008, p. 18). The assumption that food security could be assured simply because “[a]s a rich country, open to trade, the UK is well placed to access sufficient foodstuffs through a well-functioning world market” (Defra, 2006, p. iii) was brought into sharp relief just two years after it was stated. The UK was shown to be vulnerable to events which could disrupt the *status quo* to which it had become accustomed, and further, that *status quo* was demonstrated to be rather more fragile than had been thought.

The UK's food security agenda was then developed by the publication of papers by interested parties from both government departments and NGOs such as the Soil Association. Almost concurrent with the release of Defra's (2008) *Ensuring the UK's Food Security in a Changing World* was the Cabinet Office Strategy Unit's report *Food Matters* (2008). Not focussed on food security *per se*, which was to be expected given that the concept had only recently entered the national policy making lexicon, the paper addressed a range of issues concerning the provisioning of food in the UK, and also began to outline a strategy for the years ahead. At this point, discussion around food security continued to remain centred on its consideration from the interconnected market perspective. As the document argues, “fair prices, choice, access to food and food security [should be achieved] through open and competitive markets” (Cabinet Office, 2008, p. iii). It then goes on to observe that “[f]ood security policy is properly focused on the availability, accessibility and affordability of food and is thus concerned with matters such as the diversity of supplies and the resilience of the supply chain to shocks” (Cabinet Office, 2008, p. 32). Later that year, the Soil Association released their own response to the Defra report (Barling et al., 2008). Their interpretation was critical of the Defra

outlook, arguing that "Defra's recent formulation of a set of indicators to measure UK food security marginalizes the real challenges facing food supply in the near future. The impression is of a set of indicators and a policy mind-set rooted in the recent past rather than looking to the future" (Barling et al., 2008, p. 2). For the Soil Association, there is an urgent need to consider what they call the "new fundamentals"⁵ which, they suggest, will frame the future challenges of food production. In short, responding to these new fundamentals entails principally the engendering of "resilience" (Barling et al., 2008, p. 27).

The move from food security as a state to food security as process, a move discussed earlier in this section, plays out in the emerging conceptualisation of food security through the terminology of resilience⁶. Crawford Stanley Holling is one of the most widely cited thinkers on the resilience concept, positing that, in ecological terms, resilience reflects the greatest level of disturbance a system may tolerate while still being able to return to its former equilibrium (Holling, 1973). Developments to the concept have come about since Holling's pronouncements (Walker, Holling, Carpenter, & Kinzig, 2004), and it has since been employed fairly frequently in conversations on food security (Almås & Campbell, 2012). Of particular importance in the theoretical debate are the notions of adaptability, or "the capacity of actors in a system to influence resilience", and transformability, "the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing

5 The 'new fundamentals' proposed are made up of issues surrounding climate change; water; biodiversity and ecosystems support; energy and non-renewable fossil fuels; population growth; land; soil; labour; dietary change; and climate change and public health (Barling, Sharpe, & Lang, 2008).

6 In academic discourse, the employment of the terminology of resilience is somewhat contested (Scott, 2013, p. 598). There is brief discussion of the term here because of its employment in this branch of the policy literature. However, in this thesis more widely, I have elected to grapple with similar ideas through the lens of temporality.

system untenable" (see also Almås & Campbell, 2012; Walker et al., 2004, p. 5). As the Soil Association's new fundamentals show, efforts to build a resilient food system, by which I mean one able to survive, adapt or transform such that it maintains its ability to bring about food security, inherently entails engagement with both the human and nonhuman aspects of the food system (see Whatmore, 2002; for further discussion of this area of theory, see Chapter 3). It also necessitates an engagement with the temporalities (Anderson, 2010) of the food system, by which I mean the way practices lead to intersections of past, present and future.

One Defra report (Defra, 2008), for example, elicits the notion of the future by basing their discussion on food security on, to quote their title, its place in a "changing world". In a move indicating a more explicit regard for the future, the House of Commons' Environment, Food and Rural Affairs Committee, a committee whose role is to examine the work of Defra and its associated bodies, produced the report *Securing Food Supplies up to 2050* (House of Commons, 2009). Crucial to these discussions is the idea of risk, which can be understood in the context as an event or occurrence which might harm the resilience of the food supply and thus reduce food security. The House of Commons report was prepared specifically in response to Defra's aforementioned publication. It welcomes Defra's assertion that they will, in due course, publish a detailed assessment of future risks to UK food security (House of Commons, 2009, p. 35), which Defra do indeed go on to do (Defra, 2009). In this later document, risks to future food security are explicitly foregrounded (Defra, 2009). The document notes four types of risk, political, technical, demographic and economic, and environmental, and cross cuts these with six key themes, global availability, global resource sustainability, UK availability and access, UK food chain resilience, household affordability and access, and safety

and confidence. Plotting the types of risk against these key themes has been done, it is avowed, in order to represent both the breadth and the interconnectedness of the types of risk the UK food system could face (Defra, 2009, pp. 12–13).

For the most part, the kind of risk foreseen in Defra's (2009) report and its predecessors is that of sudden, dramatic events. However this ignores another crucial aspect of risk, as the Soil Association points out: "[m]ost discussion of food system resilience talks about 'shocks' to the system, but slow attrition is another form of threat" (Barling et al., 2008, p. 42). Responding to slow attrition requires arresting that attrition before it sets in, or by working to ameliorate the effects of it if it has already begun. For the Soil Association, such attrition shows itself in a lack of commitment to the support of UK farming, though attrition may manifest itself in other related ways too. One possible response to the risk of diminished future food security as a consequence of the slow attrition of the food system (however, one unlikely to receive the support of the Soil Association itself given the intensive nature of the agriculture it calls for) comes about in the practice of what has recently been termed "sustainable intensification" (Royal Society, 2009). In short, the term implies increased outputs alongside a reduction in environmental footprint. This may take the form of continuous development of crop plants in ways which are intended to maintain or improve biomass output while simultaneously reducing the need for expensive or environmentally damaging inputs. To promote resilience and thus strengthen the chance of future food security, the Royal Society called for a tranche of science-based innovations in the food system, which it outlined in the document *Reaping the Benefits: Science and the sustainable intensification of global agriculture* (2009).

Sustainable intensification in the form called for by the Royal Society would be achieved as follows. Increasing biomass output from plants can be done in two ways: first, by the application of agrochemicals such as fertilizer to encourage growth or pesticides to reduce crop damage, or, second, by encouraging the plant to more efficiently capture nutrients and enabling it to ward off pests through its own resistance techniques. Historically, agriculture has entailed the two in combination and for the foreseeable future that is likely to remain the case. However, for the Royal Society, approaches which reduce inputs are preferable from both an environmental and economic perspective (Royal Society, 2009, p. 7). Thus, they favour an approach in which plants' own biological processes produce the outcomes that external inputs would otherwise have engendered. Understanding gene function and the genetic improvement of crop plants is thus posited as one of the central ways that improvements can be made to food security (Royal Society, 2009, Chapter 3). To make plants undertake tasks they did not previously undertake requires the inclusion of the trait or combination of traits that confers the desired function into the plant's genetic makeup. Plants must be altered, either by genetic modification or conventional breeding, to include the desired material. These traits are complex. Designer genes or tailor-made traits created through genetic engineering will remain the stuff of science fiction for years to come (Barnes & Dupré, 2008). As such, the traits need to come from somewhere. The world's major crop plants are the result of many decades of careful breeding. The gene pools of well used varieties have successively honed down such that they perform superbly in the conditions for which they were designed, but this leaves little room for manoeuvre. Thus, useful traits must be bred in from other plant varieties, and this may be done in the ways outlined in the Chapter 1.

The irony of food security

The point at which we arrive is one tinged with irony. The risk of food insecurity has the potential to be reduced by the breeding of plants better able to produce food in the quantities needed in the conditions they may, in future, face. Yet agriculture's encroachment onto ever larger areas of land, and the greater diffusion of improved seed to increase outputs in the present, has led to an increasing homogenisation of varieties farmed. As such, agricultural genetic diversity in both wild and field conditions has reduced, leading to a possible reduction in the availability of the traits which may be of utility in future. As such, the irony here is that in reducing food insecurity in the present we risk also reducing our ability to create food security in future.

This is because, many of the traits we may need in future are or were found in the varieties that were once carefully cultivated and frequently grown. Already, as a consequence of this, some potentially useful genetic material has been lost as a result of once common agricultural varieties or their wild relatives having become extinct (Fowler & Mooney, 1990). To reduce the risk of these losses continuing, efforts have been and continue to be put in place prevent further extinctions. The storing of seeds in seed banks is one way to keep varieties from extinction, and, moreover, those banked seeds are the resources required for the crop genetic improvement called for by the Royal Society. They note that "[m]aintaining and enhancing the diversity of crop genetic resources is vital to facilitate crop breeding and thereby enhance the resilience of food crop production" (Royal Society, 2009, p. ix). The Government Office for Science's Foresight report *The Future of Food and Farming*, which focusses in part on the breeding of plants agrees (2011a). They expand on this point in the associated Synthesis Report, stating:

In optimising yield and other beneficial traits the genetic variation in major crops ... has often become much reduced and in some cases virtually zero. ... This has two consequences: first, valuable [resistance] genes in plants and other traits for genetic resistance may become lost; second, the genetically homogeneous crop is an easier target for natural enemies to adapt to. The preservation of multiple varieties, land races, rare breeds and closely related wild relatives of domesticated species is very important in maintaining a genetic bank of variation that can be called upon to combat natural enemies.

(Government Office for Science, 2011b, p. 13)

In short, I argue that the practice of banking seeds, which I shall now go on to explore, is one undertaken because it is thought likely to help bring about future food security.

Conserving seeds and genes

Calls for the conservation of seeds in ways which echo those of the Royal Society cited in the section above date back decades. As early as the mid-1930s, biologists were warning of the consequences of declining genetic diversity in food and agriculture (Harlan and Martini 1936, p. 136, in Harlan, 1975, pp. 618–619). Yet, it was not until the 1970s that the discussion really gained traction, when it was cautioned that “[w]e continue to act as though we could always replenish our supplies of genetic diversity. Such is not the case” (Harlan, 1975, p. 621). More recently, Cary Fowler and Pat Mooney have reiterated the dire consequences that could come from disregarding this conservation imperative:

Loss of genetic diversity in agriculture – silent, rapid, inexorable – is

leading us to a rendezvous with extinction – is leading us to the doorstep of hunger on a scale we refuse to imagine. To simplify the environment as we have done with agriculture is to destroy the complex interrelationships that hold the natural world together. Reducing the diversity of life, we narrow our options for the future and render our own survival more precarious. It is life at the end of the limb.

(Fowler & Mooney, 1990, p. ix)

The result of these concerns has been the gradual establishment of *ex situ* preservation facilities, a term commonly used for gene or seed banks, which are presently relatively widespread. These have been useful for both public and private plant breeders, as well as those working on basic plant science (Brown, Marshall, Frankel, & Williams, 1989). In this section I will explore this story in detail, working through the emergence of the technology of seed banking, considering how the material stored came to be known through the terminology of plant genetic resources, and looking at the questions and conflicts which have punctuated seed banking practice from its inception to the present.

However, before doing this, I will briefly consider the origins of this genetic diversity. To summarise the narrative laid out by Fowler and Mooney (1990, Chapter 2), the varieties of food plants available to humanity today are the consequence of several thousand years of of natural and human selection the world over. Since the emergence of settled agriculture, and certainly long before genetics arrived as an explanatory tool for inheritance of traits over generations, farmers have saved for the following year the seeds of plants which exhibited favourable characteristics during the current year. Doing so led to the development of what are now termed landraces. In today's terminology these are groups of genetically similar crop types which broadly express a

coherent set of traits when grown. There may, in the past, have been, for example, hundreds or even thousands of wheat landraces selected by farmers to suit the environmental conditions they were to be grown in and the preferences that farmer or group of farmers held which made the crop particularly suited for their needs.

Seed banking's beginnings

As Fowler and Mooney then show, it is the Russian scientist Nikolai Vavilov who, from his research in the 1920s and 1930s, is widely credited for having identified this diversity (Vavilov's story was outlined in greater detail in Chapter 1). Vavilov realised that genetic diversity was not equally distributed around the world, rather it was focussed in hotspots, or what he termed centres of diversity, located in the central latitudes of the earth. He worked in an age where Mendelian inheritance (see Bateson, 1902; Henig, 2000) was understood, and, drawing upon this theory, he concluded that the materials growing in these centres of diversity could be sources of useful traits conferring characteristics such as pest and disease resistance. On his research trips, he would collect seeds for his Leningrad seed bank which was, in its time, the most comprehensive in the world. Diversity may be focused in these hotspots, but that is not to say that it is limited to them. In every country there exist landraces which represent the variation in agricultural practices from the distant and recent past. Additionally, the wild relatives of crop plants, the grasses from which grain crops are derived, for example, also act as a source of potentially useful variation. The loss of this diversity, whatever its cause, is termed genetic erosion (see Fowler & Mooney, 1990, Chapter 4).

An awareness of genetic erosion and the consequences it could have for agriculture led to what Robin Pistorius has called the plant genetic resources

"movement" (Pistorius, 1997). In 1967, the UN FAO and the International Biological Programme called a meeting named the Technical Conference on the Exploration, Utilisation and Conservation of Plant Genetic Resources. The discussion at this meeting set the direction for plant genetic resource preservation in the years that followed. Critically, it was here that the debate as to which of *in situ* preservation (the preservation of plant varieties by ensuring their continued growth in the field year on year) or *ex situ* preservation (the preservation of plant varieties as seeds in seed banks) was the preferred conservation practice. It was a hotly contested debate which took in contrasting opinions of both scientific and ethical practice (the debate is outlined in Pistorius, 1997, Chapter 2), yet it was a consequence of its technical ease and comparatively lower cost that *ex situ* preservation techniques triumphed (Pistorius, 1997, p. 29).

That said, the calls for *in situ* conservation have not gone away. *In situ* conservation is useful because "it allows a complex of populations to be preserved and evolutionary processes to be continued" (Veteläinen, Negri, & Maxted, 2009, p. 6). Indeed, as the same authors argue, its practice in conjunction with *ex situ* strategies could confer greater benefits than the former alone:

The goal of applying the two conservation strategies is ultimately to serve the present needs of plant breeders on one hand, and the need to maintain genetic resources that are always in tune with the environment to deal with future unpredictable changes on the other hand.
(Veteläinen et al., 2009, p. 7)

Further, it is the fact that *ex situ* conservation techniques are so directed

towards the mainstream plant breeding (Pistorius, 1997, p. 39) regime that makes it moot to some. The above authors are not explicitly critical of *ex situ* gene banking, although there are others who are. Renée Vellvé, for example, considers what she regards as the "genebank or bust" approach (the phrase with which she titles her third chapter), which she argues to have been taken by European biodiversity conservationists, as being "almost worse than the [genetic erosion] problem" (Vellvé, 1992, p. 67). Her critique is wide ranging, taking in institutional, political, technical and biological concerns. For Vellvé, as she argues in her final chapter, a wholesale reconsideration of what is sought to be achieved by banking is needed if seed banking is to be anything other than "simple seed museum mechanism" (Vellvé, 1992, p. 138). Others agree. Thom van Dooren, in a paper published in *Science as Culture* (van Dooren, 2009), presented a manifesto for what he regarded as good seed banking, or seed banking that was being done well:

Ultimately, the paper argues that it might be possible to 'bank well', but that these practices must be premised on conserving 'biosocial' natures, on understandings and systems of banking in which resources are not stockpiled, but are rather shared and kept moving in more-than-human agricultural communities.

(van Dooren, 2009, p. 374)

Van Dooren's proposal on how seed banking may be done well is located in a broader debate about what exactly seed banking is, particularly with reference to how seeds become plant genetic resources, something he regards in a negative light. He draws upon the work of Hayden (2003, discussed earlier in this chapter) in support of this view. Reflecting on her study of the accumulation of biological material intended for use in the research setting,

Hayden argues that this practice leads to a change in what is meant by the idea of nature. Van Dooren makes a similar reflection, arguing that the nature of seeds when they become plant genetic resources is neither what it use to be, nor what it should be. As plant genetic resources, seeds become mere utilitarian tools. In van Dooren's words, "a particular kind of nature is being imagined and produced here. More specifically, my position is that these projects do not aim to conserve agricultural biodiversity at all, but rather aim to protect *and make readily available for use* a unique kind of instrumentalised genetic life" (2009, p. 375 emphasis in original).

Critical commentary on conventional seed banking

Van Dooren goes on to draw a comparison between two seed bank case studies, one which specialises in staple grain crops and which caters for a mainstream science and research audience, and one which deals in heritage vegetable varieties and whose users are predominantly hobbyist gardeners and small scale agriculturalists. He is critical of the former for what he sees as the the instrumentalised version of life it conserves. By comparison, he approves of the version of seed banking which deals in heritage vegetable varieties. He regards this as banking well because of the way it conserves agricultural biodiversity in a more authentic fashion, working not merely on keeping plant material in existence but keeping it, and the stories and knowledge associated with it, in circulation amongst users. "The natures that [this bank of heritage varieties] imagines and creates are very explicitly biosocial ones, in which people, crop plants and diverse others come together. Plants are not simply genetic data here, or even just fleshy bodies that nourish, rather, they carry in and with them possibilities for ways of living and knowing the world" (van Dooren, 2009, p. 386).

In comparison to the relative paucity of social science writing on conventional forms of seed banking (the two key monographs on the banking of biological materials explored in the first section of this chapter being the closest examples of such work), this kind of critical approach, by which I mean one focussed on the merits of alternative seed banking practices, is common in the literature. This could be because such analyses fit easily into established frameworks of power and resistance which dominated cultural geography in the 1990s and early 2000s (see Pile & Keith, 1997). As Derrick Purdue (2000) shows, members of the wider public involve themselves in the informal *in situ* networks admired by van Dooren and Vellvé for a variety of reasons which tend to reflect their broader political or cultural world views. While for some, these networks are largely about providing the materials sought by hobbyist gardeners or allotment growers (Stickland, 1998) others see such seed networks as enmeshed in a more comprehensive set of political arguments around the working of today's mainstream food systems. For Vellvé, there is an urgent need to reform the way we produce our food. She argues that we need to move "in a direction that integrates the social and environmental dimensions of agriculture, those so called 'externalities' that economists currently ignore. Genetic diversity is a vital component of both these dimensions." She continues by noting that "[c]onservation of folk seeds is doomed if it is delinked from production, and our farming systems are in dire need of diversification" (Vellvé, 1992, p. 129). Rather than regarding informal seed savers and conventional agricultural biologists as working in separate spheres, the food system she espouses would see the gaps between the two bridged (Vellvé, 1992, p. 138). Writing later on, Virginia Nazarea (2005) makes similar calls.

Geographer Catherine Phillips (2005) also regards such seed saving as being political, but takes a rather different track in doing so. Interested in the

interface of the human and nonhuman, she draws on her research into Canadian seed saving networks to argue that seed saving is a political act because it embodies "a set of practices valued by growers and consumers interested in supporting more sustainable socio-natural systems" (Phillips, 2005, p. 39). Rather than understanding the politics of seed saving through the lens of a set of opposing intellectual frameworks, she explores the way that seed savers' "everyday practices of saving seed [may be regarded as] as a kind of political engagement" (Phillips, 2005, p. 39 emphasis added). For Phillips it is the acts of doing seed saving, the messy socio-natural engagements entailed in plant growing, that are of interest. As was alluded to above, seed saving is usually about the formation of networks too, as growers connect with one another to exchange both seeds and plant growing knowledge. In the light of this, seed saving is regarded as being a kind of activism and Phillips, somewhat hesitantly, frames this politics around the idea of green citizenship – the formation of a community around particular ecological political lines.

Kloppenburg's First the Seed

One exception stands out to the above noted paucity of social science literature on conventional seed banking. Although nearly three decades old, Jack Kloppenburg's (1985) *First the Seed* remains to this day the most comprehensive analysis of seeds and seed banking written in the social sciences milieu. Although there is greater parity in themes and research technique used in this thesis and those of the earlier discussed texts on the banking of biological materials (Hayden, 2003; Parry, 2004), I incorporate Kloppenburg's work into my discussion at this point for two reasons. First, as a significant text, leaving it out would be to fail to comprehensively embed this thesis in the literature which surrounds it; and, second, because both in terms of the building of a narrative of plant genetic resource accumulation and

utilisation, and the later exploration of the politics of that practice, both having been significant discussions in this chapter so far, are also explored by Kloppenburg.

Commensurate with much intellectual work of its era, Kloppenburg's unpicking of the American biotechnology sector from its inception, which he ties with Columbus's 1492 arrival on the continent, to the, then future, year 2000, is written from an avowedly Marxist perspective. Because of its anti-corporate agenda, this stance does reflect the politics of more recent critiques of seed banking practice the like of which were discussed above. His aim is to examine the technologies of the political economy of the then emerging biotechnology sector in order to demonstrate that its workings, rather than representing a radical break from the past as so often they are presented, instead "are introduced into a particular set of social, economic, and ecological circumstances with with *established* and *knowable* trajectories" (Kloppenburg, 1985, p. 4 emphasis added). As Kloppenburg describes, the genetic foundations of American agriculture came about from a concerted effort at germplasm collection from by overseas American military and diplomatic personnel from the early 1800s onwards, a practice echoing modern day bioprospecting. In its early stages, seed collection and testing was undertaken by the US Department of Agriculture as a publicly run concern. The Department undertook a rudimentary experimental regime, dispatching seeds to farmers around the country and encouraging them to grow them out and report on their experiences.

Yet two key changes in the workings of agriculture saw what had once been a public activity move into commercial hands. Kloppenburg (1985, Chapter 4) first cites the emergence of market gardening, a practice which developed as

cities expanded and food supplies were needed for their inhabitants. While traditionally farmers would save seeds from their crops from which to grow the following year's produce, for market gardeners this was economically unviable as harvesting seeds meant allowing them to mature in fruits or vegetables which could otherwise have been sold. As such an external source of seeds was needed and a market grew to supply this need. The second big change (Kloppenborg, 1985, Chapter 5) was the rediscovery of Mendel's work (see Bateson, 1902; Henig, 2000) in the early 1900s. With the lessons of Mendelism, plant breeding came of age as organisations were able to improve varieties to increase production. This did not in itself create a market as saving grain seeds, unlike vegetables', was easy and incurred little additional cost, thus remaining the norm well into the 1900s. It was Mendel's discovery of hybrid vigour which really created the market. Mendel had shown that creating hybrid seeds, seeds produced from two genetically identical parents, would result in a first generation of offspring which grew vigorously and which were highly productive, but with generations that followed growing very poorly. Seed companies realised that if they focussed their efforts on hybrid seeds they could create a situation where farmers were forced to return as seed buying customers year on year.

For Kloppenborg, then, it was the enrolling of seeds into the capitalist market as the products of a plant breeding industry, and then the efforts to facilitate the working of that market, which led to the emergence of the international plant genetic resources networks which now exists. (Again, this part of the story echoes strongly the narratives of biological material's market incorporation through bioprospecting.) These networks are affiliated with, although not necessarily directly connected to, international institutions like the UN FAO. He outlines the paths the networks' organisations took to becoming

the significant global players they are today. Though the international nature of those networks is often noted as demonstrative of their legitimacy in the face of critical political commentary, Kloppenburg is unconvinced. The names of the organisations have changed in the years following Kloppenburg's analysis, yet many of today's critics in alternative seed networks cited above would echo the sentiment he expresses:

The [International Agricultural Research Centres] are not only a mechanism for encouraging capitalist development in the Third World countryside, they are also vehicles for the efficient extraction of plant genetic resources from the Third World and their transfer to the gene banks of Europe, North America, and Japan. ... The [International Board for Plant Genetic Resources] has further institutionalized the historically asymmetric flow of genetic resource between the Third World and the capitalist societies of the Northern Hemisphere. Coupled with the continuing failure to stem the process of genetic erosion, this asymmetry has potentially ominous implications.

(Kloppenburg, 1985, pp. 161–166)

In summary, seed banking, the practice examined in this section, entails work in the present with the materials of the past, whereas food security, examined in the section preceding this, entails work in the present with a view to bringing about improved future scenarios. As such, the practice of seed banking for food security is predicated upon engagements with the past, present and future. Therefore, I attest that it is through the framework of temporality that seed banking for food security is best understood. In the following section, I examine thinking on temporality as it has been developed by the area's key scholars.

Past, Present, and Futures

As Barbara Adams and Chris Groves state, the future is not abstract and indeterminate. Rather, it unfolds as a consequence of that which is undertaken in the present – indeed, as they put it, it is “*living within the present*” (Adam & Groves, 2007, p. 121 emphasis in original). However, as Adam and Groves note, there has been a tendency across academic disciplines towards the “fiction of an empty future” (2007, p. 13). Moreover, much academic thinking has tended to “treat the future as if it were a space and/or matter ... as if it was a territory that can be colonised and traversed, or as a material resource to be used and consumed” (Adam & Groves, 2007, p. 101). This has particular resonance in the discipline of geography. In a recent literature review published in *Progress in Human Geography*, Ben Anderson (2010, p. 778) noted that, while many of geography's main research areas intrinsically entail some kind of engagement with the future, with the exception of some arguably less frequently pursued research agendas such as the geographies of science fiction (Kitchin & Kneale, 2001) or utopias (Jameson, 2005), geographers have tended not to think or write according explicitly temporal terms. This may generate a serious intellectual problem, as Anderson goes on to note: “The risk is that we repeat a series of assumptions about linear temporality; specifically, that the future is a blank separate from the present or that the future is a *telos* towards which the present is heading” (Anderson, 2010, p. 778).

The act of rendering the future, by which I mean its conjuring imaginatively in academic work or other intellectual products, may also be understood as a kind of temporal folding whereby the future is brought into the present. Anderson terms such activities “anticipatory practices” (2010, p. 783), and works through three modes by which he perceives others in the academy to have hypothesised that the future is made present: calculating futures, imagining futures and

performing futures (2010, pp. 783–787). To calculate futures is to render the future visible through the production of numerical data about that future. It is a technique that has most been used by insurance and related financial industries who have most commonly used data on past catastrophic events to predict multiple possible outcomes should such an event reoccur. Imagining futures, the first of two more qualitative techniques of futuring, entails the creation of narratives about what the future may be like. These narratives could take the form of case studies, pictures or stories, and have commonly been used, for example, in explorations of post-climate change futures. Imagining futures is useful because it enables one to create a series of possible expectations about future events without making explicit predictions on what the future might be like. The final mode of futuring Anderson discusses is that of performing futures, or making the future present through kinds of embodied activity like role play or scenario acting. As Anderson shows, such practices are undertaken most commonly by governments or organisations who seek to examine the way they might respond to a large scale crisis event such as terrorist attack or war situation.

Making the future present imaginatively or intellectually is not itself an end point. Rather it is a part of a more extensive engagement with the future, specifically, an engagement in which, in one way or another, the individual or organisation doing the imagining is also seeking to modify or otherwise intervene in that future. Having outlined three modes of knowing the future, Anderson moves on to discuss three ways, or logics, that might be employed in order to engage with the making of the potential futures that could follow. The three key logics he identifies are precaution, preemption, and preparedness (Anderson, 2010, pp. 788–792). Precaution is a preventative logic which is both separate from the the process it acts upon and which acts before the identified

threat reaches a point of irreversibility. Efforts to stabilise greenhouse gas emissions at levels predicted to be low enough to prevent the most serious changes to the earth's climate are one of the clearest examples of our time of action which follows the precautionary principal. The notion of preemption follows this. Unlike precaution, which responds to events which either already exist or have the possibility to do so, the aim of preemption is to stifle threats before they have even emerged. Preemptive logics came to define the so called War on Terror which punctuated the first decade of this century. Finally, Anderson cites preparedness, a logic which at its centre accepts the likelihood of an event or threat taking place and seeks readiness for its aftermath. It is interested not in preventing the event itself, but reducing as far as possible the effects of that event.

There is a politics to such engagements with the future in the present. Put simply, actions in the present, which are themselves based upon imaginative or intellectual formulations of possible futures, are argued to play a role in the way the future ends up turning out. This is a very different assertion to saying that such practices definitively bring about futures, because the future can never be inevitable. However, as such, there is cause for reflection on the ethical implications of actions in the present upon futures eventually brought into being. Adam and Groves (2007, 2011) discuss how the practice of good ethical futuring might be understood intellectually. Their thesis is centred around the notion of care. They discuss how current maxims to comprehend actions which have impact on others are centred on the idea of responsibility. Such maxims are backward looking, and their working relies upon "evidence of causation" (Adam & Groves, 2011, p. 18). Although, at first glance this, does not in itself sound problematic, difficulties emerge when such a way of thinking is extrapolated onto the complex events of the wider world. The authors argue

that most events of significance currently in train, such as climate change or financial mismanagement, are too complex for responsibility to be accurately directed after the event.

A change of tack is needed such that “we view responsibility as something we actively *take* rather than something that is imputed to us when we are held liable for something” (Adam & Groves, 2011, p. 19 emphasis in original). Such an epistemological approach would lead to a reorientation of our thinking from retrospection to a forward looking approach, forcing engagement with the consequences of actions on others before those actions are undertaken rather than afterward. In drawing these two strands together, the authors suggest that “[t]he stronger is this sense of participating in projects that connect us with future generations, the stronger will be our sense that near and distant futures both matter to us now” (Adam & Groves, 2011, p. 25). In sum, Adam and Groves are calling for way of engaging with the future which, rather than assigning blame for mistakes, seeks to work toward the bringing about of futures in which fewer mistakes are made.

I make reference to these ideas around temporality in order to set up a framework by which they can be employed to understand seed banking for food security. Indeed, as was outlined in Chapter 1, the idea of temporality is central to the second of the three subquestions assembled to assist in responding to my central research question. In short, I regard the development of the concept of food security to be, in Anderson's terms, an anticipatory practice, where the future is conjured imaginatively and engaged with in the present. Such an engagement should be understood as an example of good ethical futuring, where responsibility for future events is taken in the present, rather than blame for failings applied after the event.

Conclusion

In this chapter I have examined several strands of literature directly relevant to seed banking and food security. I began by locating the thesis within two comparable studies and an area of scholarship which explore acquisition, preservation and utilisation of biological materials in technoscientific settings. Attention to these studies provided a helpful intellectual and empirical backdrop to this thesis, but also exposed a gap in the literature on the work of banking biological materials. Specifically, its practice in the food milieu was demonstrably unexamined. As such, in the remainder of the chapter I explored the literature necessary to ground my examination of the practice within that milieu possible. I began by considering the concept of food security, beginning with the term's development and moving on to its employment in the present. However, I showed there to be a paradox linking food security with the conservation of plant genetic resources. This played out as, by bringing food security about in one time, something achieved through the utilisation of modern and highly productive varieties to increase yields, future food security was reduced due to the loss of access to crop genetic diversity. Seed banking, a technology which had been around for some time, was invoked as a solution. Hence, in the third section, I examined seed banking practice from its earliest instigation to its current undertaking. Food security and seed banking are linked together by their relationship with time. Specifically, my argument is that each is centred on actions undertaken in one time with the intention of engendering consequences in another. In order to investigate this, I examined arguments around how temporality is thought to function.

Having explored the literature around the topics of my research area, in the following chapter I turn to examine the theory by which I conceive of, and

examine, those topics.

Chapter 3: A materialist theoretical approach

Introduction

In the previous chapter, I located my research directly within its scholarly milieu, exploring a literature addressing debates around seeds, seed banking, and food security. In this chapter, I turn to consider the theoretical frameworks of materiality, relationality and politics which will underpin my examination of those subjects in ways specific to this thesis.

In so doing, I also set out to demonstrate how I shall answer the research question and its associated subquestions, as outlined in Chapter 1, specifically the first and third of them (the theory underpinning the second having been examined at the close of Chapter 2). Theoretically, the thesis will be guided by an approach which puts materiality at its centre. I shall be attentive to the workings of seeds as material objects, and to the way those materials come to interface with the world around them in practice through the framework of a food security setting. As such, I use this chapter to make a case in support of the materialist infused theoretical approach necessary to do this. In particular, in spite of critical commentary from some quarters, I shall make a case for an understanding of materiality hinged upon that of actor-network approaches.

The chapter is divided into three sections, each of which contributes a separate but related element to the argument. The first section addresses discussion of the material in social sciences. I begin at a point at which the material had largely been written out of the scholarly conversation, with interest directed instead to the cultural as a tool of analysis and explanation. In recent years

what has been termed a materialist return (Whatmore, 2006) has been underway across the social sciences, and, in particular, in some areas of Geography⁷. This part of the chapter traces the contours of this return, and, in so doing, makes the first arguments in support of an actor-network approach to the material over alternative theoretical conceptions such as that of the commodity. As I shall argue, I favour this theoretical route because it directs attention to the agency of materials. Rather than viewing objects as passive elements within a human directed system, actor-network approaches recognise the roles they play as agents within the working of the world at large. However, as I also show, this move towards actor-network approaches has not been universally approved of. While the calls to recognise the interface of nature and culture (Latour, 1993) are widely agreed to be necessary, particularly in the light of the increasing recognition of human impacts upon the nonhuman environment, there has been some debate as to whether the actor-network approach is the one best placed to respond to these issues. In this section of the chapter, I highlight this argument, although, citing later scholarly responses in support of my position, I go on to argue against it.

The second part of this chapter considers the interface of objects and practices. If, as I argued in the first section, objects are agentic, or, in other words, they play a role in bringing the world into being, then, as I will argue in this section, they must do so in a relational fashion. Hence, in this section, I explore that relationality. In doing so, I examine two key concepts. First, I offer evidence for the broad notion of relationality by looking at a pair of ways by which objects

7 Although this thesis is written in a Geography department and is inflected, through the subject matter, the literature cited and its theoretical purview, with the geographical, for the most part I have avoided making specific reference to the discipline in my writing, preferring to retain an interdisciplinary element to my work. However, within the materiality discussion, and in particular way I shall address it in the first section of this chapter, there is a very specifically geographical story to be told. It is for this reason that I make reference to geography here in a way that does not occur elsewhere in the thesis.

have been suggested to interact with the wider world: the concept of the fluid object (de Laet & Mol, 2000) and that of the immutable mobile (Latour, 1987). Second, I develop that concept of relationality in ways specifically pertinent to the direction of this thesis, arguing that, through their being practiced in different ways at different times and in different places, objects become multiple (Mol, 2002); or, in other words, they become "more than one – but less than many" (Mol, 2002, p. 55). Together, the theory explored in the first and second parts of this chapter direct my later answering of the first of my research subquestions, which asks "How do seeds become the materials of a food security agenda?".

The theory of the final section of this chapter directs my response to the third subquestion, "How do seeds function as politically engaged materials?". In this final section I consider the way politics is played out within an actor-network approach rooted in the examination of practices. The concerns some scholars have voiced with regard to the adoption of actor-network approaches, cited in the first section, are echoed here. As such, I open the section by giving voice to a debate around the possibility and efficacy of politically relevant work within an actor-network framework. While the critical discussion around actor-network approaches cited earlier called for their rejection, here, the argument is for their modification. I examine the contribution work around controversies has made to the way I have framed the research in this thesis. I then move on to consider several scholars, whose work is attentive both to the interaction of humans and the material and in Marxist philosophy, have called for something they term "weak ANT" (Castree, 2002; see also Kirsch & Mitchell, 2004; Routledge, 2008), a version of the actor-network approach which is intentionally less than fully symmetrical. They do so, in order that actor-networks and Marxism can be made to co-exist theoretically. I review this

argument but reject it as a possible tool for political engagement. Instead, I argue in favour of a version of politics termed "ontological politics" (Mol, 1999), which fits with the wider theoretical requirements of the actor-network approach and, therefore, better addresses the kind of political arguments I shall go on to make in the thesis. In particular, I argue for a version of politics that, instead of seeking the incorporation of research findings into pre-existing theoretical frameworks, of which Marxism could be just one of many examples, instead seeks to address the specifics of each event it witnesses. As such, I argue for a version of politics which looks for ways to do things "well" (reflecting van Dooren, 2009, whose work is also examined in Chapter 2).

Within this theoretical chapter, illustrative material is include in order to justify the theoretical approaches for which I argue in favour. Although illustrative material which considers seed banking or food security directly is, for the most part, unavailable, I do cite literature from empirically related areas, in particular those attentive to the material agency of plants or to discussions around food and agriculture. I begin the chapter by turning, now, to the re-emergence of scholarship attentive to materiality by a section of the academy who had previously disregarded it.

Materiality's return

Writing in *Area* in 1987, Dennis Cosgrove and Peter Jackson said of culture that it was "the medium through which people transform the *mundane phenomenon of the material world* into a world of *significant symbols* to which they give meaning and attach value" (cited in Mitchell, 1995, p. 102, emphasis added). The case for such a contention, though reflective of the interpretive and textual direction of scholarly practice in much social science's cultural strands at the time (consider Duncan, 2005 [1990], as an exemplar), would be less easily

made in the equivalent strands today. For, far from being regarded as mere "mundane phenomenon", much contemporary thinking in many (although not all) areas of the social sciences holds the "material world" (Cosgrove and Jackson in Mitchell, 1995, p. 102) to be one of the principle loci of study and theorisation. In this thesis, which is centred on the practices of seed banking and food security, analysis of the difference materials such as seeds make will be a central component. Consequently, the mode by which these materials are to be addressed requires examination. In this section, I first offer a brief outline of the route by which interest in the material returned to some key arenas of academic thinking following its period of elision. In so doing, I outline two modes by which materiality has received academic attention in recent years: one rooted in commodities, and the other in actor-network approaches. I make a case for the latter, which is the one I shall pursue in this thesis. I illustrate the discussion in each part by drawing upon materiality literature selected from the areas of food and agriculture, and of plants, in order to demonstrate the significant role this thinking has had in relation to research agendas which have a broad parity with the subject matter of this thesis.

Ceasing to be "less attentive"

The comments of Cosgrove and Jackson, which opened this section, are cited in Don Mitchell's (1995, see also 1996) pathbreaking challenge to cultural geographers of the era to think again about the ontological effects of employing culture in an explanatory capacity. Like the work of Nigel Thrift (1991), who postulated that cultural geographers had become so attentive to the words used to represent things and actions they had come to omit from consideration the things and actions themselves, Mitchell's piece marked a moment in a wider sense of "anxiety" (Anderson & Tolia-Kelly, 2004, p. 669) about what the cultural turn of the 1990s was doing to the position of the material in academic

geographical thinking. The sentiment was echoed by Chris Philo, who states:

I am concerned that, in the rush to elevate [the cultural] in our human geographical studies, we have ended up being less attentive to the more 'thingy', bump-into-able, stubbornly there-in-the-world kinds of 'matter' (the material) with which earlier geographers tended to be more familiar. (Philo, 2000, p. 33)

Within this debate, two key issues were raised. The first spoke specifically to the discipline of geography: "With the advent of the 'new cultural geography'," Sarah Whatmore observed, "this *earthlife* nexus [the particular interest that geography has, as Whatmore puts it, in "the vital connections between the *geo* (earth) and the *bio* (life)"] was written out of, or more accurately, into the ancestral past of cultural geography" (2006, p. 601, emphasis in original). The second was a broader epistemological point. As Karen Barad asked, "[w]hat compels the belief that we have a direct access to cultural representations and their content that we lack toward the things represented? How did language come to be more trustworthy than matter?" (2003, p. 801).

In response to these observations came, in geography, as elsewhere in the social sciences, a series of calls for the direction of attention away from culture's intangibility and toward "bump-into-able" (Philo, 2000, p. 33) materials. But this marked only the start of a conversation known in shorthand as the re-materialisation debate (Jackson, 2000; Lees, 2002) or the materialist return (Whatmore, 2006). Though there is a history of work in geography that attends to the material in ways more overt than those of cultural geographers of the late 1990s (Whatmore, 2006), commentators emphasised that the vocabulary of bringing material back were not merely calls for reiteration of the

versions of materiality that had gone before:

Increasingly, there are, therefore, a series of productive divergences in how matter, and materiality, are encountered in the twists of the cultural turn. ... Given these differences there can be no simple 'return' to 'matter' or to 'the material'.

(Anderson & Tolia-Kelly, 2004, p. 672; see also Anderson & Wylie, 2009)

So, while the call for materiality was widespread, and its importance recognised – the notion that “matter matters” (Barad, 2003, p. 803) – the terms by which that materiality was to be addressed remained subject to debate.

Having considered the calls for materiality in general, my next step is to consider the contours of the versions of materiality which ensued in fields related to my research. My aim in doing so is to develop the narrative outlined above, whilst also arguing for the particular concepts which will underpin this thesis. As Anderson and Wylie (2009, p. 318) demonstrate, some distinct clustering is exhibited in the geographical research lines which have most overtly responded to the call of materiality. The three areas they highlight are material cultures; nature, science and technology; and the lived body, emotions and affect. In order to provide a grounding of the materiality story in a way pertinent to my work, I will briefly consider the first of these clusterings before making a detailed examination of the second. I disregard examination of the third on the grounds that, although there is some interface between studies of food, agriculture and the corporeal (such as Dyke, 2011), that area of research is not of direct relevance to the broad conversations of this thesis.

In a series of monographs, the anthropologist Daniel Miller has outlined a

comprehensive set of empirical tools and theoretical arguments around the impact of the material on popular culture (Miller, 1998, 2005, 2010). Peter Jackson, already cited in this chapter as a significant proponent of a materialised human geography, references Miller's work as having strongly influenced his own (Jackson, 2000, p. 10). The work of each centres on materials tied up in the cultural networks brought about through the concept of commodity, a concept examined by another anthropologist, Arjun Appadurai, in his edited collection *The Social Life of Things* (1988) (for a detailed examination of commodity cultures and geography see Jackson, 1999, 2002).

Engagements with materialism through the concept of commodity have been undertaken by various authors interested in issues of food and agriculture (as surveyed by Cook et al., 2006). Ian Cook, in his own work, calls for an approach centred on "follow[ing] the thing", whereby the effects of food production, such as those social, economic or environmental, are identified by the tracking of the material foodstuff from the location of its production to that of its consumption (Cook & Harrison, 2007; Cook, 2004, p. 200). Such an approach is echoed in Susanne Freidberg's monograph *French Beans and Food Scares* (2004). In general terms, there is some limited crossover between the work in this area and the work in this thesis. Thing following in studies of food and agriculture, in ways similar to the ethnographic approach taken in the fieldwork of this research (to be discussed in Chapter 3), enables the working up of a more complex story than mere physical linkages, facilitating the tracing of networks spatial, cultural and economic that develop between materials, producers and consumers in an increasingly interconnected world. This is useful. However, there are two key features missing from this approach which I shall outline with reference to the work forthcoming in this thesis.

The first, quite simply, is that the commodity approach cannot encompass all that takes place within food and agriculture. Although, in seed banking, materials move from place to place in ways highly significant to their part in seed banking systems, and, indeed, these movements are at times mediated by financial exchange, to regard seeds solely as commodities in this process would be to miss a range of other critical areas⁸. More importantly, the second is a theoretical point related to the agency it has been argued that materials have in directing the workings of the networks within which they exist. Within commodity networks, the commodities themselves are not considered to be active parts of the formation of those networks, rather they are simply objects whose movement occurs thanks to the work of the human actors in charge. As I shall show in this thesis, I regard the recognition of that agency to be essential. Because it offers a tool by which to access and investigate that agency, I am, therefore, more convinced by the work on materiality which has come from approaches in the actor-network milieu. This quotation from Karen Bakker and Gavin Bridge gives an indication of the central tenets of such a framework:

[T]he material' is more than just a call for a heterogeneously populated world: it is also an acknowledgement that the 'things' (commodities, bodies, biophysical processes) that make a difference in the way social relations unfold are not pre-given substrates that variably enable and constrain social action, but are themselves historical products of material, representational and symbolic practices.

8 Particularly as within seed banking, which is an entirely separate entity to the commercial seed market from which farmers purchase the seed they intend to sow, almost all exchange is non-commercial. Seed banks are usually owned by the state or non-government and non-profit-making organisations (indeed, this is true of all those examined in this thesis), for whom the exchange of seed is a tool to ensure its free availability, with benefits for food security and biodiversity conservation.

Materials, agency and actor-network approaches

The actor-network approach is well suited to the examination of the materiality of seed banking and food security. I am in agreement with the critique levelled by David Goodman some years ago, who argued that "the theoretical purview and contemporary political relevance of agro-food studies are significantly weakened by their methodological foundations" (Goodman, 1999, p. 17) (see also FitzSimmons & Goodman, 1998; Goodman, 2001). Goodman's opinion was that the study of food and agriculture in the social sciences was stuck in a "modernist ontology" which ultimately led to research whose foundations were based on the intellectually imprecise "dualistic separation of nature and society" (1999, p. 17). Goodman saw a potential for advancement arriving were future work to incorporate into its theoretical lexicon the thinking of actor-network approaches (see Latour, 2000), in which dualisms are elided and the world is regarded as a place of hybrids; a place, in other words, where "[a]ll of culture and all of nature get churned up again every day" (Latour, 1993, p. 6). Goodman praises actor-network approaches for the relationality they incorporate in their attending to concepts like materiality, and nature and society, suggesting that such a way of working is better able to grasp the issues that contemporary studies around food and agriculture must face (for arguments in favour of actor-network approaches across geography more broadly, see Murdoch, 1997, 1998). He, writing with colleague Margaret FitzSimmons, illustrates his argument with discussion of BSE and anorexia. Each is an example of what he calls "incorporation", a term employed to represent the interface between the practices of food production (broadly standing for nature) and the corporeal (broadly standing for society) (FitzSimmons & Goodman, 1998).

Goodman's call was not received without criticism. Terry Marsden queried both the assertion that a non-actor-network infused approach resulted in quite the narrowness of theoretical or empirical scope that Goodman implied, and the argument that, if indeed there is a narrowness, it is best resolved by the adoption of actor-network understandings (2000). On one hand, I agree with the implications of Marsden's first point, that there remains some considerable merit in the pre-existing scholarship not written from an actor-network approach. However, on the other and in ways I will argue for in this chapter, I do believe that an adoption of actor-network approaches in at least some areas of research would improve its outputs. In some senses, Marsden's critique echoed many of those made in the early period of the actor-network approach's employment by those outside the social studies of science arena in which it was developed (such as the case made for "weak ANT" (Castree, 2002) by some political geographers). Though cognisant of the need to break the dichotomy between nature and society in work on food and agriculture, Marsden seeks to avoid being required to abandon the social, political, economic and other explanatory frameworks already extant in social science. It is in the light of the demand for the relinquishing of these frameworks that he argues the actor-network approach to be "methodologically strong but substantively weak" (2000, p. 24).

The critical tenet of actor-network approaches, and the one with which Marsden was most at odds with in making his argument that the actor-network approaches are "methodologically strong but substantively weak" (2000, p. 24), is that of its focus on description rather than explanation (Latour, 2005a, p. 144). Drawing on Latour's text, *Reassembling the Social* (Latour, 2005a), I argue that this is not the case. Marsden's comments indicate a fundamental

misunderstanding of what actor-network approaches aim to achieve. Latour makes pains to emphasise that the actor-network approach is not supposed to be a theory judiciously applied to research findings as though it were a tool for interpretation, rather it is to be understood as a new mode of understanding the configuration of the world with the consequent adjustments to the the research and writing process that this entails⁹. In other words, Marsden's mistake was to regard actor-network approaches as being something to be used or applied in an explanatory capacity, rather than seeing it as a new route toward explanation.

In this context, the call for description rather than explanation makes considerably more sense:

The reason for this change of tempo is that, instead of taking a reasonable position and imposing some order beforehand, ANT claims to be able to find order much better after having let the actors deploy the full range of controversies in which they are immersed. ... The search for order, rigor, and pattern is by no means abandoned. It is simply relocated one step further into abstraction so that actors are allowed to unfold their own differing cosmos, no matter how counter-intuitive they appear.

(Latour, 2005a, p. 23)

9 This is why I have carefully made reference to actor-network *approaches* in this thesis, rather than using the more common nomenclature of actor-network theory or ANT. In a general sense, the the term actor-network theory is inadequate for describing the complexity of the framework to which it corresponds, and consequently is described by Latour as being "so awkward, so confusing, so meaningless" (2005a, p. 9). However, as he goes on to note in the same text, it is in part that association which comes in particular from being described as a "theory" which underpins its being regarded as a merely tool to be applied rather than a framework through which a broader reconceptualisation of the world at large is called for (Latour, 2005a, p. 141).

It is for these reasons that I argue for the employment of actor-network approaches as a tool to access materiality and, indeed, as a research tool more generally within this thesis. Description, and the observatory research that goes into that description, enables access to the complexity of the way things occur in a way which takes in the work of all of the actors, both human and nonhuman. My argument rests on what I regard to be the effectiveness of this approach in the numerous examples which have followed Goodman's call for the incorporation of actor-network arguments in scholarship of agriculture and food, and in wider research settings.

The approach has been followed, to cite merely a recent selection, to draw out broader discussions in research areas as diverse as salad leaves (Stuart, 2011), fish (Mansfield, 2011), and wheat (Atchison, Head, & Gates, 2010). Casting the net more widely, there also exists a literature in which this has been discussed in cases related to plant materiality. In their research project on nonhuman agency, Paul Cloke and Owain Jones produced a series of case studies about places in and around Bristol in which, they suggested trees might be understood as agentic in place making in a cultural sense (Cloke & Jones, 2002; Jones & Cloke, 2008). Through careful observation of the presence of trees and the things those trees did, such as the way they grew, the shade they provided, and the landscapes they changed, trees as material objects were found to make an active and meaningful difference to the places that they grew in. This they did in ways which went beyond their being interpreted by culturally aware humans as those in earlier traditions of landscape would have argued. In a similar way Russell Hitchings argues for the agency of plants in the creation of the spaces of private gardens (2003), and Paul Robbins examines grassed urban landscapes as being ones coproduced by people, grasses, weeds and

chemicals (2012). Indeed, actor-network approaches are widely employed within research both in the arena of food and agriculture, and indeed across the social sciences at large.

Vital materiality

Having made a case for the employment of actor-network approaches in my dealings with materiality in this thesis, in closing this section I shall examine a particular version of materiality which draws strongly upon the actor-network approach. This version has been termed "vital materialist" by Jane Bennett in the argument she makes for it in her monograph *Vibrant Matter* (2010). Bennett allies herself with Latour's attempts to develop a theory of distributed agency¹⁰. Rather than agency being the sole possession of humans, she sees the world as being home to "vibrant matter and lively things" which "not only ... impede or block the will and designs of humans but also act as quasi agents or forces with trajectories, propensities, or tendencies of their own" (Bennett, 2010, p. viii). Although the consequences of both Bennett's and Latour's calls to reconfigure understandings of the world such that human agency is not imagined to exist unthinkingly within a realm of inert or pliable materials, what Bennett's version offers that Latour's does not, in the terms of this thesis at least, is derived from the vocabulary of livingness she employs. Where Latour regards the world, in an arguably somewhat methodical fashion, as being populated with "quasi-objects" (Latour, 1993), Bennett sees a place of awash with liveliness and activity, in which there is always "a swarm of vitalities at play" (Bennett, 2010, p. 32).

¹⁰ For example, the parallels are demonstrated in this explanation of her theory of distributive agency early on in the text: "an actant never really acts alone. Its efficacy or agency always depends on the collaboration, cooperation, or interactive interference of many bodies and forces. A lot happens to the concept of agency once nonhuman things are figure less as social constructions and more as actors, and once humans themselves are assessed not as autonyms but as vital materialities" (Bennett, 2010, p. 21).

This terminology of liveliness chimes with my conception of seeds, the materials of this thesis. In Bennett's eyes, vital materiality has a number of key attributes. It cannot be discarded and instead it continues to exist even after the objects it is found in disappear from human consciousness. Her references to litter, or the potential for pollution from landfill sites, is demonstrative of this. However, typically the notion of vitalism carried with it the idea of purposefulness and agency associated only with living and indeed sentient beings (Driesch, 2012, cited in Bennett, 2010). Bennett's approach is different. She makes reference to things, to nonhuman and indeed nonliving materials, as having the potential for thing-power. By her inclusion of minerals, in particular the very materials that make up human bodies, she extends her argument by suggesting that even what for many is the very essence of humanity – the bodies we live in, the biochemical processes we think with – are themselves to be inflected through the lens of thing-power. Seeds can be understood in a similar way. Like human bodies, they are made up of non-living materials such as minerals which are essential actors in the bringing about and doing of life. However, the function of seeds complicates the story still further. Seeds act as the bearers of plant potentiality – though its viability is measured by whether or not it is metabolising, a viable seed would not itself be regarded as being alive. Yet it is from seeds that life, as it is conventionally understood, may come.

Having, over the course of this section, developed an argument in support of materialist frameworks to social science thinking, and, in particular, argued in favour of a framework centred on the actor-network approach, in the following section, I make further developments to the way I wish to attend to materials. I go on to argue that materials should be regarded as not as singular, stable

entities, but as things which can be multiple (Mol, 2002). Critical to this argument, is the notion that materials, because they are agentic or vital as I showed them to be in the present section, cannot be thought of solely as independent entities and, conversely, must be understood as existing in relation to other materials.

Relational materialities and multiple objects

The route I take in developing the argument for relational materialities is as follows. The section begins with an examination of two ways that objects have been argued to relate to the world, looking at the contrasting conceptualisations from the theory of "fluid objects" (de Laet & Mol, 2000) and that of "immutable and combinable mobiles", often referred to in shorthand as "immutable mobiles" (Latour, 1987). The two are not counter arguments, rather they recognise the different formulations that objects may take when relating to other objects. Each theory is centred around the ability of objects to retain their functionality as they move from situation to situation, or from place to place. According to the former argument, some objects are able to gain a wide diffusion by relating to the world in a "fluid" way, by tolerating manipulation or adjustment while still remaining coherent. In the latter argument, the opposite is true, and it is by resisting manipulation and remaining stable throughout their relations with other objects that immutable mobiles come to be diffused.

What this attention to fluid objects and immutable mobiles offers is foundational evidence for the core argument of this section which is that objects act relationally, and, furthermore, that this relationality makes a difference to the object itself. In the case of fluid objects and immutable mobiles, relationality makes a difference because it affects their ability to be diffused. However, relationality has another important effect on objects. The

central outcome of my argument in this section is that objects should be understood as multiple. As I shall outline comprehensively later on, objects become "more than one – but less than many" (Mol, 2002, p. 55) because of the way they relate to the world at large, or, in other words, because of the way they are practiced. The things done to objects, their interactions with other humans and nonhumans, is central to the way that objects are brought into being. As the thesis develops, and I work through the ways seeds become plant genetic resources in my empirical chapters, an understanding of this notion of multiplicity will be critical.

Fluid objects and immutable mobiles

The key paper on fluid objects is one by Marianne de Laet and Annemarie Mol (2000) who use as their case study to explore the concept, a water pump found in various villages across Zimbabwe. The pump has been widely installed with the aim of ensuring that villagers have access to a reliable supply of clean, safe, potable water. In short, in their paper the authors argue that this pump, a particular type of pump called the "Zimbabwe Bush Pump 'B'", is a successful object (in that it both works for villagers by allowing them access to the water they need to live, and works for aid agency funders in that it has been widely installed across Zimbabwe) because it is neither obligated to remain stable due to, for example, rules laid down by its manufacturers, and nor does it need to remain stable in order to function for villagers (de Laet & Mol, 2000). In other words, the key to its success, as measured by its wide diffusion across Zimbabwe, is that there are no precise contours the object is required to follow in order for it to function successfully; some parts of its makeup – although not all – are open to modification, adjustment, or utilisation in ways neither intended nor foreseen by the manufacturer. Indeed, the authors go further than merely stating that the bush pump may survive as a coherent object even when

it is altered. They contend that, in fact, its adaptability actually facilitates the travel of that object; in other words, were it not so adaptable, it would not have become so ubiquitous.

By contrast, immutable mobiles rely on their unchangingness to move from place to place. Latour introduced his concept of immutable mobiles in his text *Science in Action* (Latour, 1987). Like *Laboratory Life* (Latour & Woolgar, 1979), this was a text in which Latour was investigating the practice and function of knowledge creation through science. The concept of immutable mobiles referred to the way by which scientific theories would remain stable even as they were moved from place to place. In other words, theories or facts hold their shape both in and of themselves and in terms of their relations with other objects. Latour demonstrates the concept with reference to star charts. Because the night sky is unchanging, astronomers who have mapped that sky have been able to build a comprehensive set of data about what it is like which are consistently accurate over both time and space. "All these charts, tables and trajectories are conveniently at hand and combinable at will, no matter whether they are twenty centuries old or a day old; each of them brings celestial bodies billions of tons heavy and hundreds of thousands of miles away to the size of a point on a piece of paper" (Latour, 1987, p. 227). However, immutable mobiles need not only be facts, the theory also accounts for material objects. Law (1986), in an earlier text, employs the immutable mobile argument in examining the role of sailing vessels as tools of Portuguese social control in the colonial era. He argues that the fact they maintained their shape and function, and their relationship with water, wind, currents and so forth, worked to ensure Portuguese colonial powers were able to act at a distance. Over the course of this thesis, I will draw on the notion of relationality developed, in different ways, by these two arguments as a way to conceptualise

the way seeds are incorporated into a plant genetic resources milieu.

Practicing "multiple" materials

Whether referring to the Zimbabwean villagers of the bush pump, or the sailors of the Portuguese vessels, what links the stories of these two objects is that, fluid or immutable, these are objects which are used. Objects do not have importance because of their innate qualities, but because of how they are interacted with in the world. Paying attention to practices entails paying attention to how it is that things are done, or, in other words, the ways that objects are practiced into being. The notion that objects or materials are practiced into being is indicative of an understanding that there is no fixed essence within any object, but, rather, that they come to be what they are by the way they interface with other objects in the wider world. In this part of the chapter, I shall examine how this theory has been developed through an ethnographic study of the the disease atherosclerosis, which is one of arterial obstruction, undertaken by Mol in her text *The Body Multiple* (similar theoretical work, albeit examined using a very different case example, is found in Law & Mol, 2008a; 2002). I review this literature because the examination of the role practices and the effect they have on seeds within a seed banking milieu will become increasingly significant as this thesis develops. What seeds are, in Chapter 5, and what they do, in Chapters 6 and 7, will be argued to be a direct consequence of the ways they are practiced in the seed banking milieus in which those seeds are implicated. I begin by exploring the concept of multiplicity, before moving on to discuss practices in the text which follows.

The premise of Mol's argument is that "what we think of as a single object may appear to be more than one" (Mol, 2002, p. vii). The reason it may appear to be "more than one" is because that single object may be practiced by the

various people with which it comes into contact (who, in the case of the disease atherosclerosis, could be patients, doctors, lab technicians and so forth) in a variety of ways. The act of practicing an object in a particular way, Mol argues, is also one of bringing it into being in a particular way. As such, there becomes more than one of that object. However, this does not result in a single object becoming several. In the example, in spite of its being practiced in various ways, there remains still one identifiable and coherent thing which goes by the name of atherosclerosis; these multiple atheroscleroses hold themselves together in spite of their differences. It is the same disease that different people are diagnosed with, which many people are treated successfully for in similar ways, and which, in some cases, causes death. Thus, although it may seem paradoxical, as well as being understood as being more than one, the object must also be thought of as being "less than many" (Mol, 2002, p. 55). Hence, atherosclerosis, like much else in the world, is "multiple"; it is more than one but less than many. And this multiplicity matters because recognising its presence enables the telling of more accurate stories about the way objects come to be.

Mol contrasts an ontology centred on practices with one, which she rejects, centred on perspectives. According to a perspectivalist viewpoint, there would be only one atherosclerosis that would be perceived differently by the patients, doctors, lab technicians and so forth that were mentioned previously. There would not be multiple atheroscleroses, only multiple people's viewpoints. However, the key reason for rejecting the perspectivalism approach, is that atherosclerosis is not only something known and perceived, it is also a "physical reality"; by addressing it only as a representation to be perceived, Mol suggests, that physical reality gets "left out" – "[t]he disease *recedes* behind the interpretations" (Mol, 2002, pp. 11–12, emphasis in original). Considering

the disease in practice confers benefits to our understanding of what atherosclerosis is, and too, what it is to have atherosclerosis. "This illness is something being done to you, the patient. And something that, as a patient, you do" (Mol, 2002, p. 20).

As such, being and doing become interconnected concepts. Mol outlines her thinking on this matter as follows:

Somewhere along the way the meaning of the word 'is' has changed.

Dramatically. This is what the change implies: the new 'is' is one that is situated. It doesn't say what atherosclerosis is by nature, everywhere. It doesn't say what it is in and of itself, for nothing ever 'is' alone. *To be is to be related*. The new talk about what is does not bracket the practicalities involved in enacting reality. It keeps them present.

(Mol, 2002, p. 54 emphasis in original)

Through extensive ethnographic study, Mol works through the various ways atherosclerosis is practiced. In following it to places ranging from the diagnosis techniques of blood pressure testing in the consulting room, to the patient's files, and to the day to day lived experience of the disease, Mol concludes that the disease is a "composite object" (2002, p. 71) that is held together by "coordination" (2002, p. 83). That being so, it should not be regarded as a given that these various enactments should necessarily hold together perfectly. Incoherences, such as the patient who exhibits what the diagnostic instruments suggest should be a serious case of atherosclerosis but who, upon questioning, does not claim to be feeling the discomfort associated with atherosclerosis, can coexist in an object that is more than one but less than many. Because reality is distributed, this can happen so long as "different 'sites' are kept apart" (Mol,

2002, p. 88).

Indeed it can be something as simple as pragmatism which determines the way by which atherosclerosis is enacted. The example of treatment is used to illustrate this. Even though the cause of atherosclerosis is the build up of deposits on the inside of the arteries, treatment is not limited to one mode of surgical removal of those deposits. The choice of treatment type is an outcome of a host of factors which influence the final decision. But the key point is that, once atherosclerosis is regarded as something multiple, these differences in enactment cease to matter. "Distributions separate out what might otherwise clash" (Mol, 2002, p. 115). The term atherosclerosis acts to coordinate a variety of different practices and enactments into one object. Should there be discrepancies in that coordination, in treatment for example, they only become problematic if each different treatment option were used at the same time, if the multiple realities were not distributed. Furthermore, at times when realities cannot be kept apart, such as at the point when the patient who suffers from atherosclerosis both as a social condition and an arterial condition, the one need not encompass the other, rather it can be said that they are "situated *side by side ... next to one another*" (Mol, 2002, pp. 149–150, emphasis in original).

Attending to that doing, or rather, attending to the practices of that doing, requires a new research methodology, and thus Mol proposes the notion of "praxiography" (Mol, 2002, p. 31). Praxiography is a version of ethnography in which practices and their doing are foregrounded¹¹. In so doing, the places in which atherosclerosis takes place are shown to be far more diverse than within the arteries of the diseased patient. Indeed, atherosclerosis is done in other

¹¹ An approach which demonstrates the utility of description as a research method, echoing the discussion of Latour (2005a) in the debate between Goodman (1999) and Marsden (2000) undertaken in the previous section.

places where the patient may not be present at all; for example, in a laboratory where a cross section of an artery is viewed by technicians under a microscope (Mol, 2002, pp. 29–30). I mention this now, for although this is not a methods chapter (a discussion of praxiography and methods in this thesis will occur in Chapter 4), attention to the function of methods is useful in drawing out a wider point. Being concerned with practices is to be concerned with what it is that those practices reveal. And what they reveal, Mol argues, is that “in practices objects are *enacted*. This [the concept of enactment] suggests that activities take place – but leaves the actors vague. It also suggests that in the act, and only then and there, something *is* – being enacted” (Mol, 2002, p. 33, emphasis in original).

Mol's interest in practices also serves as a way of reconsidering the divide between subjects and objects. Like Latour (1993) and others who follow an actor-network approach to materiality (cited in the section above), she is suspicious of the dichotomy of subject and object, human and nonhuman. But this is not all: “I want to escape from this dichotomy *twice*,” Mol claims (2002, p. 32, emphasis in original). The second version of the dichotomy concerns knowing, specifically the idea of “a distinction between knowing subjects and objects known” (Mol, 2002, p. 46). This matters, because what an attentiveness to practices reveals is that knowledge does not reside simply in the subjects of knowledge, but it resides in the objects of that knowledge too. By understanding that there is no single way to transfer knowledge between subject and object and that instead each is symmetrical, the enactment thesis makes more sense. Throughout the medical practice that goes into atherosclerosis, its diagnosis, management and treatment, knowledge is found to be distributed throughout the objects of the illness as well as its subjects – in, to repeat the earlier case study for example, both the slide and the viewer

of the slide. A study of enactment through praxiography gives access to all these sites of knowledge.

In the chapter so far I have achieved two key tasks. I have demonstrated first that attention to the material is a necessary part of some areas of social sciences scholarship, and argued that, for the purposes of this thesis, the actor-network approach is the most appropriate way of accessing it. Additionally, I have argued that materials should be understood relationally; that what they are is not a consequence of anything innate but, rather, is a consequence of how those materials relate to the world. This leads to the formation of objects which are multiple, which through their relations with practice may become more than one but less than many. Having arrived at this point, there is one further step I wish to make in my examination of materiality. As Divya Tolia-Kelly argues:

As a result of the capacities of the geographical conceptual realm, there are several moments where there has been a surge towards a notion of 'new' materialisms and orientations. Occasionally, the promise of the imagination within the research process to refigure the worldly materializes, whereas in other accounts there is simply only a shallow engagement presented. This is where the political engagement with the concept of material is absent; this is what I term a surface geography. In these research projects, there is use of the concept of 'materiality', but without any reflection, critique, engagement or evaluation; leaving a surface recording, a description, a mapping or illustration of materialities within a site or those which are observed.

(Tolia-Kelly, 2012, p. 1)

In the final section, then, I turn attention to political practice in materiality.

Politics

Political debate abound in both academic and popular writing on the subjects of food, seeds and plant genetics. These take in a huge diversity of areas, ranging from the science of genetic modification in food production (such as Ruse & Castle, 2002) to the diffusion of improved seed in the context of green revolution agricultural development (such as Shiva, 1991). Further, as I demonstrated in the previous chapter, there are numerous debates within the seed banking milieu itself. In related work, the political roles played by animals have been examined (Hobson, 2007), as too have those of non-living materials (such as Hawkins, 2009) (see also Barry, 2001; Bennett, 2010; Braun & Whatmore, 2010). An attentiveness to materiality and the nonhuman, for which I argued in the previous sections, offers a novel angle through which to rethink the ways the world works politically. Indeed, I agree with Tolia-Kelly who argues, in the quotation cited at the close of the previous section, that to not engage with the political in research which examines the material is to undertake only a "shallow engagement" with that material, producing work with an interest merely in the "surface" of its subject matter (2012, p. 1).

As such, in this section, I will examine various proposed routes towards a politics of materiality centred on actor-network approaches, in order to establish a framework for the discussion of the politics of seeds, seed banking and food security later in the thesis. I begin by working through an exchange between Gerard de Vries and Bruno Latour in which the two debate how politics might come to figure in actor-network approaches. In the second part of this section, I show that such a way of doing politics has not met with universal approval. Here, I examine the arguments against a purely actor-network

inflected version of politics in favour of one which espouses a “weak” version of that approach, whereby preexisting political frameworks may also be implicated (Castree, 2002). While interested in the case made by this call, particularly because it emerges from an academic milieu common to my own – that of research around the environment and conservation in Geography, I contend that the broad framework set up by de Vries and Latour enables a more productive analysis of the workings of politics.

Hence, I argue in favour of a version of politics, termed ontological politics, which operates from inside the actor-network approach (Law & Mol, 2008a, 2008b; Mol, 1999, 2002). This version builds on the notion of the enactment of multiplicity. Although political contest is not the inevitable outcome of multiplicity, the approach suggests that if the world is one in which various possibilities may be enacted into being, then at times it may be necessary to make a judgement as to which possibilities it is preferable to enact over others. Indeed, one of the key ideas from this work, as I shall later show, is that of how one might do something *well*.

Latour and de Vries' exchange

A critical moment in the arrival of a soundly political inflection to actor-network approaches came in the course of conversation mediated by an exchange of papers between Latour and de Vries. While the subject of the conversation was not new – indeed, in *The Politics of Nature* (2004), Latour had called for the reconfiguration of the concepts of both politics and nature, endeavouring to elide the preconfigured descriptive work of each with a view to reinvigorating the sphere of political ecology – the terms of this conversation were different. De Vries, in opening the discussion, argued that his central concern with actor-network approaches was not their failure to grapple with politics at all, but

rather that they did so in a way which did not reflect the radically novel nature of the wider assertions they were making about the world. In other words, and while signalling his broad agreement, Latour phrased it in his response by stating, "we were so busy renewing some of the features of scientific practice that we took off the shelf whatever political theory we had" (Latour, 2007, p. 812).

De Vries' argument is that politics has long ceased to be limited to "what is going on in official national and international political institutions" (2007, p. 782), and is dispersed into all parts of society. Following terminology developed in work published separately by Ulrich Beck and Mark Bovens, de Vries terms this diffusion "subpoliticization" (de Vries, 2007, p. 782). Efforts to reinstate the role of democratic politics by making it a decision making mechanism able to engage with subpolitics came about in two forms: one which sought to broaden the scope of democracy through a new layer of advisory and regulatory organisations, and another which sought to engage with the subpolitical by increasing participation and representation. However, these projects were limited in efficacy because, de Vries contends, what is to be included under the banner of subpolitics remained unsettled (de Vries, 2007, p. 783). Furthermore, so did the question "[w]hat in fact *is* politics?" (de Vries, 2007, p. 788, emphasis in original).

He goes on to explore the origins of the vocabulary of politics and democracy as it came about in Ancient Greek society, arguing that what this vocabulary engenders is one of a "community of mini-kings", where citizens, persons with "preferences, interests, aims and plans", collectively make decisions based upon intellectual engagement with issues (de Vries, 2007, p. 791). However, although such a framework where decision making is separate from, and leads

to, action "covers many familiar situations ... important aspects of human action are not included" (de Vries, 2007, pp. 791–792). Specifically, and drawing from Aristotle, de Vries argues that what is left out in the "community of mini-kings" model is the politics enmeshed within the acts of doing; in other words, the politics of *praxis*. "In *praxis* the means-ends dichotomy collapses. ... The aim of *praxis* is the activity itself; the point is in the act, not in the mind of the actor" (de Vries, 2007, p. 792, emphasis in original). Consequently, the core argument is that:

[t]o be in or out of politics is not a matter of the opinions that are aired, but depends on whether an actor is involved in a *praxis* that aims at a political object, or not.

(de Vries, 2007, p. 798 emphasis in original)

Latour's response is one of broad agreement with both the premise of de Vries' argument and, in part, the response he formulates. However, in contrast, he does not solely seek a return to Aristotelian theory (Latour, 2007, p. 814). Rather, Latour bases his argument on the importance of attending to the way politics circulates around issues. He states that:

contrary to most philosophies, science studies, has made us realize retrospectively, that politics has always been *issue-oriented*. ... [Hence,] the key move is to make all definitions of politics turn around the issues instead of having the issues enter into a ready made political sphere to be dealt with.

(Latour, 2007, pp. 814–815)

In other words, Latour's argument was not that de Vries was wrong in his

pronouncement that some issues should be understood politically through an examination of praxis, but rather that he pronounced it to be the only way to understand things politically. Instead, "[e]ach new issue deserves its own protocol" (Latour, 2007, p. 818). The notion, which I now go on to explore, of the controversy act as a way of engaging with politics within the actor-network milieu and reflects the importance Latour places on considering how politics turns around issues.

Controversies

The terminology of controversy is employed in instances where humans, materials and practices come to interface in, what Whatmore terms, "moments of ontological disturbance" (Whatmore, 2009, p. 587). In other words, controversies come about not when matters are settled or events progress as expected, but rather at times of disruption such that "the things on which we rely as unexamined parts of the material fabric of our everyday lives become molten and make their agential force felt" (Whatmore, 2009, pp. 587–588). In so doing, the knowledge claims which surround such events are opened up as subjects for debate and contestation, as Nortje Marres explains.

For Marres, following the two early twentieth century thinkers Walter Lippmann and John Dewey, instead of being a problem for democracy, a paucity of information or a paucity of understanding may actually serve democracy. This is because, it is "[t]he emergence of a strange, unfamiliar, complex issue [which acts as] an *enabling* condition for democratic politics" (Marres, 2005, p. 211 emphasis in original). In other words, issues already known about have associated responses already established, while, by comparison, those which arrive anew or which come about as a consequence of a substantial shift in form from an issue which had existed previously, are yet to have their patterns

of response established; this is because they are "problems that no one else is taking care of" (Marres, 2005, p. 212). The controversy itself then acts to bring about democracy because, by coming into being, it is the controversy which causes publics to assemble around issues. As Marres puts it, "if the public doesn't adopt the issue, no one will" (Marres, 2005, p. 212).

Thus develops what Latour has termed an "*object-oriented* democracy" (Latour, 2005b, p. 14). This is a democracy which is centred not on "matters-of-fact", particularly given that facts in contemporary democracies tend to be in short supply, but on "matters-of-concern" (Latour, 2005b, p. 19). Latour justifies this movement in the following terms:

[W]e don't assemble because we agree, look alike, feel good, are socially compatible or wish to fuse together but because we are brought by divisive matters of concern into some neutral, isolated place in order to come to some sort of provisional makeshift (dis)agreement.

(Latour, 2005b, p. 23)

Moreover, where in the past, the knowledge delivered by authoritative figures such as intellectuals, scientists or politicians might have been taken for granted, today such knowledge may be subject to debate or contestation by those who assemble around an issue. As Whatmore notes, food scares around genetic modification or BSE serve as pertinent contemporary examples (Whatmore, 2009, p. 558); as indeed does flooding, in which first hand experience and local knowledge comes to abut the modelling techniques employed in those working sectors dealing with flood risk and flood management (Whatmore, 2009, p. 594).

While this thesis draws from discussion centred on controversy, the aims of the research are rather different. What attention to the notion of controversy offers is a reminder that objects, such as seed banking, are best studied when they are in a moment of controversy, or, put differently, when things are up in the air. This is because it is at this time when new practices are being assembled and new links being forged. Though a useful and necessary process, what this thesis does not do is attempt to work through or map those controversies themselves. Rather, it makes use of the disruption in the expectations of the utility of seed banking which have come about as a consequence of the insertion of food security into its repertoire.

However, the debate around actor-networks and politics has been framed in other ways too, as the following, quite different, discussion of the possibilities of an actor-network approach inflected with Marxism demonstrates.

Marxism, actor-network approaches and geography

As Noel Castree has argued, "non-relational thinking about society and environment/humans and non-humans evidently dies hard" (2003, p. 204). He makes the point when comparing the modes of doing politics found in Whatmore's (2002) *Hybrid Geographies* with those in Francis Fukuyama's (2002) *Our Posthuman Future*. The latter text, Castree suggests, has all but disregarded the movements in thinking across the social sciences which have urged scholars to reconsider divisions between subject and object, human and nonhuman. But for some of those, Castree included, who have taken on this symmetrical ontology, have found the radical shifts in thinking it calls for a source of concern because of the consequences for politics.

In what follows I will briefly examine the difficulties he and other key authors

have with a wholesale adoption of actor-network approaches in concert with politics, and consider the ways forward they propose. In recent years, being political in human geography has tended to mean being critical, or, more specifically, being, either or both, socially and economically left wing (Kitchin & Hubbard, 1999). A significant voice of concern regarding actor-network approaches has come from the economic left, or Marxist, strand of the discipline. In short, the concern these thinkers (principally Noel Castree and Bruce Braun) have raised is that actor-network approaches, because of their understanding of the world in terms of materials with symmetrical agency, thereby disavow the notion of the unequal distribution of monetary wealth in human societies as an intrinsic base point for politics. That is not to say these critics disregard the lessons of actor-network approaches entirely. However, they would seek to follow a version in which the agency of things is present but not wholly symmetrical, and as such the traditional lessons of Marxism can still apply. This has been termed "weak" actor-network theory, or weak ANT. Castree is a key proponent of this line of thinking, contending, in a key paper, that Marxism and actor-network approaches were "false antitheses". Castree identifies that, at the time of his writing, an environmentally aware and left wing strand is emerging in geography (such issues are explored in the edited collections Braun & Castree, 1998; Castree & Braun, 2001), and posits a Marxism plus "weak ANT" approach as a suitable theoretical framework for its examination.

He outlines four concerns he has with "weak ANT"'s opposite, the "strong ANT" pursued by others in the actor-network arena (Castree, 2002, pp. 134–135). First, symmetry effaces intrinsic differences he regards there to be between some objects and others; second, that the insistence that each network is unique and that generalisations, about causal effects for example, are

impossible to make; third, that actor-network approaches resist explanation preferring only to describe; and, finally, having described those networks it then appears to be agnostic about them, or, put differently, it refuses to comment on them. The weak ANT thesis has been picked up by others in the discipline (Kirsch & Mitchell, 2004; see also Routledge, 2008).

However, I am unconvinced by the calls for weak ANT for two reasons.

Primarily, because I am uncomfortable with an approach which calls for the disregarding of what it regards as one overarching theory (actor-network approaches), only for it to be replaced it with another (Marxism); but also because I believe politics to be more complex and multifaceted than is implied by a theorisation destined always to lead, ultimately, to one response (a repetitious economics-only narrative). Instead, I am inclined to follow the version set out in the conversation between de Vries and Latour, a version which sees politics as something which is enmeshed in praxis, and which will look for the political tools appropriate to each case rather than foreclosing on them in the early stages of analysis. It is for this reason that I engage in an ontological politics framework in this thesis, the terms of which I outline in the section which follows.

Ontological politics

The concept of ontological politics has been developed in various publications, together and separately, by John Law and Annemarie Mol (Law & Mol, 2008a, 2008b; Mol, 1999, 2002). The ontological politics approach will be central to my later discussion because, in addition to the reasoning outlined in the part above and in contrast to another of Castree's (2002) concerns, within it, as will be demonstrated, is a framework for two key political activities: offering critical commentary and making political interventions. In Chapter 2, in a broader

discussion on contestations around how best to bank seed, I cited van Dooren's argument for a mode of seed banking centred on what he termed the biosocial (van Dooren, 2009). Van Dooren did not argue that seed banking which prioritises the biosocial was the best version of seed banking, rather, he argued it to be an example of seed banking "well". I make reference to his argument here not because I shall show myself to be in agreement with the conclusions he draws, but, instead, because of the parity between his mode of framing his argument and my own. Van Dooren turned to Jacques Derrida (1991) for the theoretical underpinnings for his attention to wellness. However, doing practices well also is a cornerstone of ontological politics and the one I shall go on to use. In this part of the section I explore the development of that notion of wellness, first, by examining how it is laid out in *The Body Multiple* (Mol, 2002), and then, by considering how wellness has worked as a framework for an ontological politics based intervention in a food and agriculture setting. In so doing, the theoretical groundwork is laid for the route I shall later take in making arguments as to how seed banking should be done well.

Echoing the assertions of de Vries and his call for attention to praxis cited in the paragraphs above, in the formulation of the notion of wellness through her research into medical care Mol, highlights a distinction between a version of politics which is interested in the "who" and one attentive to the "what". The "politics-of-who", as she terms it, is an increasingly prevalent narrative within medicine and is concerned with "*who* is being put, or should be put, in the position to decide what counts as good" (Mol, 2002, p. 166 emphasis in original). It is centred on a movement in contemporary medical practice toward the concept of patient choice. However, though seemingly positive, the concept has, she argues, several problems. Most significant, is the way which it leads politics to be centred on people and the decisions they make at particular

moments, and in so doing, acts to divorce those moments from the backcloth of contingencies upon which they rest. In other words, "[i]t separates decision-making moments from the series of long layered and entwined histories that produce them, as if somehow normative issues could be isolated and contained within these pivotal points" (Mol, 2002, p. 169).

The alternative to a politics-of-who is a politics-of-what. Here, rather than asking who is to decide what is good, a politics-of-what in a medical context requires the "various enactments of a particular disease" (Mol, 2002, p. 176) be taken into account in ascertaining what, in each particular case, is a good thing to do. Indeed, as she elaborates, "it may help to call 'what to do?' a political question" (Mol, 2002, p. 177). In contrast to the patient choice in a politics-of-who, a politics-of-what entails a dialogue between the patient and medical staff which takes into account the materiality of their condition to come to a conclusion about how that patient is to be treated well. Mol notes that "[l]ike ontology, the good is inevitably multiple: there is more than one of it" (2002, p. 177). In a world in which realities are enacted and multiple, there are options, a range of directions that may be taken. The political emerges in the values attached to those decisions. Doing something well, seeking to enact reality in a way that is good, or indeed enacting the right version of good (because what is good for one party might not be so good for another), is where the political lies.

These concepts are echoed in a material politics intervention that Law and Mol (2008b) have made in a food and agriculture setting. Their paper was centred on a discussion of the practice of recycling food waste from the human food chain by feeding it to pigs such that it eventually would return to be available for human consumption; in other words, the paper examined the material

politics of the practice of boiling pigswill. It was this practice, or rather the absence of it, which led to one of the biggest crises in agriculture of recent years, the outbreak of foot and mouth disease in 2001. As is outlined in the paper, the practice of boiling pigswill "makes boundaries" (Law & Mol, 2008b, pp. 135–137). It is, most obviously, a boundary point between treated and untreated food, food that risks carrying foot and mouth disease and food that definitely does not. But, in the context of a globalised meat trade, boiling pigswill makes other boundaries. Meat imports from countries in which foot and mouth remains endemic are prohibited, but legal prohibition does not necessarily prevent this in practice. Though eating the meat from animals which carried foot and mouth disease does not infect humans, it may infect pigs. As such, boiling pigswill enacts cartographic boundaries, ensuring that illegally imported and possibly infectious meat is kept separate from UK, non-infectious, meat. The formation of that boundary is also political: it distinguishes between a mode of rearing pigs well, by feeding them in a way which both recycles waste food and prevents the transfer of infectious diseases, and other, less well, possible modes of pig rearing.

The foot and mouth disease outbreak of 2001 was traced to a Burnside Farm, a farm in Northumberland which, for reasons perhaps related to cost saving, had fed pigs waste food from the human food chain without engaging in the practices that would have pushed that food over the boundary point, in other words, without having boiled it (Law & Mol, 2008b, pp. 133–134). This, as can be attested by the consequences which followed, was not an example of doing pig rearing well. Six million animals were slaughtered at a cost of £3 billion in efforts to eradicate the disease (Law & Mol, 2008b, p. 134). In the period which followed, the government brought in one key measure in order to prevent a repeat of this event: the feeding of waste food to pigs was prohibited (Law &

Mol, 2008b, p. 139).

In the context of preventing a further outbreak of foot and mouth disease, this policy shift could be regarded as an alternative mode of doing pig rearing well. However, as has already been argued, the notion of wellness is both contestable and multiple. Inevitably, having abandoned the use of pigswill, another food source had to be found to replace it. In the main, this was soy imported from South America. There is an environmental cost to the production of soy and to its export, and a social cost too. Because of wealth differentials, British farmers and so British food shoppers were able to take control of food or, at least, a food producing landscape, which would otherwise have been available for the feeding of relatively less wealthy South American people (Law & Mol, 2008b, p. 140). Meanwhile, food waste in the UK was diverted to landfill. With attention to these consequences, the extent to which this may still be regarded as a mode of pig rearing well is made open to question. Law and Mol's opinion is made clear when, specifically on the subject of food waste and referencing a Victorian English poem, they ask: "Do we still have the words we might need to call this a sin?" (Law & Mol, 2008b, p. 139).

In sum, then, what I have presented in this section is an argument for a version of politics which is firmly located within the actor-network milieu in ways drawn from discussion by de Vries (2007) and Latour (2007), rather than one tinkering at its edges in the manner of "weak ANT" (Castree, 2003). Furthermore, with reference to Law and Mol's work on foot and mouth disease and pigswill (2008b), I have argued that such a version of politics has the capacity both to make pertinent commentary on the world, and to underpin the interventions made necessary in response to that commentary.

Conclusion

Over the course of this chapter, I have set out the arguments in favour of, and also outlined in detail, the theoretical approach I shall go on to take in this thesis. Rejecting assertions that the material was considered beyond the bounds of human geographical and social scientific research, where it was once considered merely as "mundane phenomena" (Cosgrove and Jackson cited in Mitchell, 1995, p. 102), I argued instead that the material should be regarded as a key component of such research. Furthermore, I argued that it is best integrated into research practices in the ways called for by those working in the actor-network milieu. I then went on to explore the efficaciousness or agency of material. The key argument was, in the second section of this chapter, that materials act relationally; that, in other words, what materials are is a consequence of the way they interface with the world. As such, materials have the capacity to be multiple, more than one but less than many, as a result of their multiple circumstances of those interactions. Finally, I developed this argument by considering the role of materials within an actor-network inflected version of politics. I demonstrated that an approach to politics located in an actor-network milieu enables an approach to politics which is both theoretically novel and politically potent.

In making these arguments I have outlined the position I shall follow in the remainder of this thesis. Throughout this chapter I have grounded my arguments in research cases which, although rarely on the subject of seed banking itself, have considerable parity with the research topic examined here, their being attentive to plants as materials or the milieus of food and agriculture. In this thesis, the materiality under scrutiny will be that of seeds and seed banks, which are embroiled in practices of seed banking undertaken for the purposes of food security. However, prior to undertaking that analysis, I

shall examine the methodology employed to gather the project's empirical material.

Chapter 4: Research methods

Introduction

In Chapter 1, I set the framework for the research to be undertaken in this thesis. This chapter examines that research framework in greater detail, attending specifically to the methodologies adopted in the fieldwork of the project. In its three sections, the chapter examines first the theory which underpinned my research design; second, the practice of the fieldwork itself; and, third, the tools used to analyse and interpret the data gathered in order to draw the conclusions set out in the empirical parts of the thesis.

In investigating the interface of seed banking and food security, this thesis is rooted theoretically, and empirically, in the framework of actor-network approaches. This first section examines what it means to do research within such a framework, returning to my research questions detailed in Chapter 1 to consider the effects of this rooting on the research design. As I shall demonstrate, while those whose work has made them central figures within the actor-network episteme have argued the approach to be not so much a "theory" as a "method" (Latour, 1999a, p. 20; see also Law & Hassard, 1999), their meaning is very distinct from any implication that there might be a strict methodology for research in that episteme. Rather, they argue the approach is to be understood as a method or tool for a radically different way of knowing the world than that which preceded it. It is for this reason that I have located this thesis within the actor-network milieu. As I will demonstrate while exploring this way of knowing, it is one which serves to promote research practice not grounded in overarching theories or grand narratives, but instead

driven by what is observed the fieldwork setting. In other words, actor-network inflected research investigates how events play out with attention to materials and practices. As such, doing research in a way true to that intellectual framework has distinct consequences for methodological practice.

Drawing upon that theoretical framework, in the second and largest section, I outline that design and its justifications in further detail. Two datasets were employed in this thesis. The principal dataset was that derived from the assembly of case studies from two seed banks which I regarded, in ways I shall demonstrate, as being emblematic of the wider practices underway within seed banking. Reflecting the actor-network milieu's association with ethnomethodology, these case studies were constructed by a series of ethnographic visits coupled with documentary analysis and interviews with practitioners. In addition, I undertook interviews with other key informants, with the intention of broadening my general understanding and adding to the empirical base. These informants included staff at a third seed banking site, which is referenced in this thesis as a supporting study, and representatives of other organisations whose work abuts the seed banking milieu. In this part of the chapter I set out my research practice in detail and comment upon it reflexively, outlining issues faced and lessons learnt.

In the final section, I explain how I analysed and interpreted that data in order to generate the claims upon which this thesis is based. From the research practice undertaken in the ways outlined in the previous section, I accrued a large amount of textual material, specifically, field notes, interview transcripts and annotated documents. Having generated that material, I then undertook the dynamic and lively process of distilling it, formulating arguments, and assembling them into a coherent narrative form.

I now turn to the examine the theoretical underpinnings to my method.

Actor-network approaches and research

The key question driving this investigation is "In what ways does seed banking act as a tool for doing food security in practice?". This question was assembled following a survey of the literature addressing seed banking and food security, which is outlined in Chapter 2. In asking that question, I sought to

- investigate a specific activity or practice: "seed banking";
- in a way which led me to follow the actors: considering seed banking as a "tool" whose workings were to be investigated "in practice";
- at the time of disruption such that the issues within it were unsettled: as I noted in Chapter 3, seed banking is a practice which has gone on for some decades. However, as discussed in Chapter 1, I examined it at a particular moment when it was in a state of flux as "food security" was in the process of being incorporated as a driver of the practice.

Furthermore, throughout the literature review and fieldwork practice I always had a series of working subquestions. However, my approach to these subquestions was iterative. Over the course of the project, they were modified and amended to reflect findings from desk based and field research. Indeed, it was only as I became embedded in the analysis phase, that a final series of subquestions were formulated; these came to be based around the content of the thesis' three proposed empirical chapters:

1. How do seeds become the materials of a food security agenda?
2. What seed temporalities are engendered by seed banking and how do

they function?

3. How do seeds function as politically engaged materials?

As is indicated by the formulation of the main question and its associated subquestions, this thesis is rooted in an interest in the core areas of practices and materials. It sought to investigate how practices work to bring the world into being, and how materials are construed as agents within those practices. Such a rooting, led me towards a materialist theoretical approach centred in the actor-network framework (discussed in detail in Chapter 3). This framework was selected because its attention, too, is rooted in those same core areas. Additionally, my decision to follow such a route reflected the knowledge about framework I had accrued from the reading of a number of key monographs located within actor-network approaches (including Latour & Woolgar, 1979; Latour, 1987, 1996, 1999b; Law, 2002; Mol, 2002, 2008; Rabinow & Dan-Cohen, 2005; Rabinow, 1996) (see also commentary in Franklin, 1995; Ruming, 2009).

Latour has written two key texts which examine how to do research within an actor-network framework. These are *Science in Action* (Latour, 1987) and *Reassembling the Social* (Latour, 2005a). Yet, neither text offers explicit direction on the practical steps that should be followed when undertaking research in this area. As Mol (2010) has argued, to expect these texts, or indeed any actor-network inflected texts, to do so, is to have made a fundamental misunderstanding as to what it is they set out to achieve:

Since 'ANT' [Actor-Network Theory] has become an academic brand name, many authors start their articles with the promise that they will 'use actor-network theory'. Let me disappoint them: this cannot be done.

It is impossible to 'use ANT' as if it were a microscope. ... ANT is not a theory. It offers no causal explanations and no consistent method. It rather takes the form of a repertoire.

(Mol, 2010, p. 261)

John Law and Vicky Singleton develop that point, arguing that rather than having any explanatory capacity:

ANT is best treated as sensibility; as a craft or a set of practices that works slowly both on and in the world; as uncertain; as empirically sensitive; as situated; and as passionate because it stays with the trouble.

(Law & Singleton, 2012, p. 5)

However, while there may not be a set methodology for work in the actor-network field, working within that field does have methodological consequences in the ways I shall explore. As such, my intentions for the remainder of this section are twofold. First, to outline what ways of knowing are located within this "repertoire" (Mol, 2010, p. 261) or "sensibility" (Law & Singleton, 2012, p. 5), and to examine what they mean for the research methodologies of this thesis; and, second, develop this line of thinking with specific reference to recent debates in the literature around "mess" in social science research (Law, 2004).

Actor-networks and knowing

In the opening pages of *Science in Action*, Latour, parodying the sign on the entrance to the gates of hell according to Dante's *Inferno*, advises his readers to "abandon all knowledge about knowledge ye who enter here" (Latour, 1987,

p. 7). The purpose of his text is to study the workings of knowledge by examining the creation of scientific facts in laboratories, a practice achieved by making an entry "through the back door of science in the making" (Latour, 1987, p. 4), and following events as they unfold. In so doing, Latour found that the taken for granted routes toward the creation of knowledge (on truth, for example, the assumption that "[w]hen things are true they hold") should be discarded and replaced by alternative, and at times seemingly counter-intuitive, ways of thinking (such as, "[w]hen things hold they start becoming true" (Latour, 1987, p. 12)). The consequences of these ways of thinking have profound effects not only on the way scientific facts are known about, but across the workings of the social world too. Most importantly, the social, like the scientific, cannot be said to be replete with *a priori* explanations for events or practices. Rather, it works as a function of the connections and interlinkages which are underway within it. As such,

there is nothing specific to social order ... [and] 'society', far from being the context 'in which' everything is framed, should rather be construed as one of the many connecting elements circulating inside tiny conduits. (Latour, 2005a, pp. 4-5)

In short, what the actor-network approach intends to say about knowledge is that it cannot be predicated upon the presence of preformed ideas or structures. Rather, with each event, possibilities are thrown in the air and slowly come to settle in ways dependent on the specificities of each case (Latour, 2005a, pp. 79-82). This is not to say that every investigation which draws upon actor-network approaches is necessarily an inquiry into the function of knowledge. Nevertheless, such investigations instinctively draw upon such a conception of knowledge; principally, they examine the world without recourse

to pre-existing theoretical frameworks, choosing instead "to follow the actors" (Latour, 2005a, p. 12)¹².

Though located within a densely theoretical text, this is a profoundly methodological instruction. At its core is referenced a critical concept upon which the actor-network framework was developed, and a feature which remains central to the milieu, that of ethnomethodology. As Latour explains when talking of its inception amongst sociologists:

For us, ANT was simply another way of being faithful to the insights of ethnomethodology; actors know what they do and we have to learn from them not only what they do, but how and why they do it. ... [L]ike ethnomethodology, [ANT is] simply a way for the social scientists to access sites, a method and not a theory.

(Latour, 1999a, pp. 19–20)

12 That rejection of pre-existing theoretical frameworks in favour of a research technique centred on "follow[ing] the actors" (Latour, 2005, p. 12) is not a line of thinking confined solely to the actor-network milieu. Indeed, it bears a close resemblance to what is termed grounded theory. First formulated by Barney Glaser and Anselm Strauss in their text, *The Discovery of Grounded Theory* (Glaser & Strauss, 1967), and expanded upon elsewhere by those authors and others, the principal intention of grounded theory is to advocate "a move away from sterile reliance on pre-existing theory" (Hammersley & Atkinson, 2007, p. 166) and toward an academic practice in which "generating theory and doing research [function as] two parts of the same process" (Glaser, 1978, in Strauss & Corbin, 1994, p. 273). Indeed, the practice of research in the grounded theory milieu draws heavily upon established qualitative research tools (Strauss & Corbin, 1994) which may include, like in the actor-network milieu, ethnography (Charmaz and Mitchell, 2001). Though aware of thinking in this area, my decision to locate this study within an actor-network framework rests upon the framework's avowed and longstanding commitment to reflections on the roles of both human and nonhuman actors, and, more importantly, the interface between the two.

Tommaso Venturini, a colleague of Latour's involved in the teaching of actor-network approaches, has examined the methodology of following actors in great detail. He cites the instruction Latour gives to students who query how they should investigate the world: "just look at controversies and tell what you see" (Latour, personal communication, in Venturini, 2010, p. 259). Venturini unpacks this phrase, examining the consequences for social science research practice of what he regards to be the two key words within it, "just" and "controversy".

He begins with the word "just". First, reflecting the above, he notes that the term calls upon researchers not to make use of specific philosophies and procedures, but simply to be open to the world such that research is driven by "[s]urprise and curiosity" (Venturini, 2010, p. 259). Second, although aware that a fieldworker can never arrive at their research field utterly naïve and without preconceptions, the term "just" is referenced to avoid intentionally employing particular theoretical or methodological practices with a view to bringing about impartiality. Instead, it must be recognised that "research perspectives are never unbiased" (Venturini, 2010, p. 260). As such, absolute impartiality can only be regarded as an illusion, and a reduction in bias, which is the best that can be achieved, may be arrived at through the broadening of the number of viewpoints, both theoretically and methodologically. Third, researchers should make their observations with the awareness that it is those being observed, by which I mean the research participants, who are the experts in the cases being examined, not the researchers; "[a]fter all, actors are constantly immersed in the issues that scholars contemplate for a limited time and from an external viewpoint" (Venturini, 2010, p. 260).

Venturini then repeats the exercise with the term "controversy" (Venturini, 2010, pp. 261–262). He begins by noting, first, that controversies inevitably entail heterogeneous relationships between a range of human and nonhuman actors. Second, that by being live events and subject to debate, they are examples of the most dynamic forms of the social in which issues and concepts which had at one point been regarded as settled are re-opened for questioning. Third, that controversies are without the reductions and simplifications that are abound in uncontroversial scenarios because, inherent in the event being live, the actors are in the process of arguing over what shape those simplifications should take. Following on from this, and fourth, controversies are subject to debate. And, fifth, they require conflicts that arise to be negotiated between actors.

Furthermore, drawing from the work of Isabelle Stengers, Whatmore has argued for the need to challenge versions of social science investigation that act to position the researcher in a fashion "removed" from the world being researched. This, she contends, acts to render that world a mere "passive object of study" (2003, p. 90). Echoing the call to to "just look at controversies and tell what you see" (Latour, personal communication, in Venturini, 2010, p. 259), Whatmore argues that researchers should abandon the expectation of being able to "know" the world, and replace it with efforts to "describe" it; this is because, "our disposition towards the world we study is better conceived as one of craft than discovery" (Whatmore, 2003, p. 91). Such a call is centred on a critique of an understanding of fieldwork where "the researcher does all the acting while the researched are merely acted upon" (Whatmore, 2003, p. 90). For Whatmore, the outcomes of fieldwork are the outcomes of a shared labour in bringing the world into being; one in which the research participants, both human and nonhuman, work alongside researchers in the making of the field

being studied.

The observations and concerns about method voiced in Whatmore's argument, and in Venturini's exploration of Latour's statement, "just look at controversies and tell what you see," are brought together by Law in his monograph, *After Method*. In this text he makes a number of observations about method, which hinge on the inaccuracy of the following assumption:

[T]he 'research methods' passed down to us after a century of social science tend to work on the assumption that the world is properly to be understood as *a set of fairly specific, determinate, and more or less identifiable processes*.

(Law, 2004, p. 5, emphasis in original).

In other words, research methodologies have routinely been based around the belief that the world, whether social or scientific, is out there and awaiting discovery by researchers. However, for two reasons, this is not the case. First, for reasons of positionality. Positionality is important here, not necessarily because of the way one's personal attributes might impact upon the research process in the ways classically argued by social science (in the way of England, 1994; or Rose, 1997), but because, as Law asserts, "methods, their rules, and even more methods' practices, not only describe but also help to *produce* the reality they understand" (Law, 2004, p. 5, emphasis in original). What is more, the world is disordered and complicated, or "messy" as Law terms it; it is replete with a "cacophony of patterns" (Law, 2004, p. 116). Consequently, a more appropriate way of investigating the world is needed than one which serves as little more than "a methodological version of auditing" (Law, 2004, p. 6). This is particularly so because "attempt[ing] to be clear" (Law, 2004, p. 2)

by doing research through frameworks in which “[w]e are being told how we must see and what we must do when we investigate” (Law, 2004, pp. 4–5) – in other words, those frameworks which Law critiques – “simply increases the mess” (Law, 2004, p. 2).

By researching and writing this thesis, my intention has always been to offer a contribution, however modest, to understanding seed banking and food security, not to generate increased mess. In what follows, I examine Law's argument in further detail in order to outline how I went about this.

Researching seeds without increasing “mess”

By undertaking a research project on seeds, seed banking, plant genetic resources, and food security, I was playing a role, albeit a small one and one in conjunction with the many other actors also enrolled in those practices, in bringing all those objects into being. As Law puts it:

Reality is neither independent nor anterior to its apparatus of production. Neither is it definite and singular until that apparatus of production is in place. Realities are made. They are *effects of the apparatuses of inscription*.

(Law, 2004, p. 32, emphasis in original)

However, this is not to say that seeds, seed banking, plant genetic resources, food security, and in the intersections between them would not have existed had I not undertaken this research. What is more, “[t]o say that something has been 'constructed' along the way is not to deny that it is real” (Law, 2004, p. 39). What a recognition of the researcher's role in bringing realities into being illuminates is their choice of which of the possible realities they chose to bring

into being, and which they do not. In other words, by taking an actor-network inflected approach to reflexivity in method I am able to recognise the "method assemblage" (Law, 2004, p. 41) of my research.

Central to the method assemblage concept is the notion that, in spite of the noise and disorder of the world at large, one is still able to recognise patterns and draw conclusions. Law likens this ability to a radio receiver, because of the way this piece of apparatus which can tune in on a specific wavelength and so disregard the white noise surrounding the desired broadcast; in other words "crucial to all method assemblage is the need to distinguish signals from noise and so to create silences" (Law, 2004, pp. 116–117). Any piece of research (but particularly those based on ethnomethodologies, as work in the actor-network milieu tends to be) has the capacity to generate the investigative equivalent of white noise, that being too much data or data of the wrong sort. As such, as well as creating data, fieldworkers must also be able to create silences; they must be selective with the data they gather and the data they then go on to interpret, leaving some of it out in order that coherent patterns, or academic arguments, can be formed with that which remains. Therefore, in comparison to the majority of methodology literature which focusses on the collection of data, the contention in Law's method assemblage is that of equal importance is the disregarding of parts of that data. In making this argument, his key aim is to remind researchers that this occurs, and thus to be cognisant of the work it does in the making of reality, and so be sure "to not foreclose on the realities that might be made too soon" (Law, 2004, pp. 117–118). Instead,

we [should] keep the metaphors of reality-making open, rather than allowing a small subset of them to naturalise themselves and die in a closed, singular, and passive version of out-thereeness.

(Law, 2004, p. 139, emphasis in original)

Law identifies two modes by which data is left out. The first, "manifest absence", are the "'out-there' realities" which are reflected in the "in-here statements" made as a consequence of research; the examples given are of "natural phenomena, processes, methods" - in short, anything which is necessary for the presence of the material being studied but which is not, in itself, of direct interest for analysis (Law, 2004, p. 42). In the study of seeds, seed banking and food security, the manifest absences are data left out of the thesis, the materialities and practices which hold seeds, seed banking and food security together, but which did not cohere into the argument as a whole. The second way by which knowledge is left out is "Otherness" (the capitalisation is Law's). This is "the endless ramification of processes and contexts 'out-there' that are both necessary to what is 'in-here' and invisible to it"; the matters considered so mundane they come to be unnoticed (Law, 2004, p. 42).

Otherness might include the reliability of an energy supply to power seed bank refrigeration systems, or the existence of an international science and research infrastructure which makes seed banking a worthwhile practice to undertake.

Attention to the method assemblage concept has tangible impacts on the research process. One may modify one's data collection practice to ensure that one is not unthinkingly accumulating data to levels that become unmanageable. Furthermore, the knowledge of the research setting which comes with an extensive period of ethnography plays a role in the recognition of the patterns which, as investigation into these areas is intensified, may develop into research findings (Law, 2004, p. 108). In my fieldwork, preliminary research visits and literature searches were used to help identify such patterns before arrival in the field. In this way I was able to formulate a research scheme

centred on case studies and a supporting study which, by definition, led to the Othering of those seed banks whose cases were not studied. Likewise, I made efforts to take seriously matters which might easily have been Othered, by endeavouring to question the backdrop of the data assembled. Of course, while it is impossible to know what difference that might have been made as a result of considering that which was not considered, being attune to Othering was a fruitful exercise in this project. For example, the examination of what occurs when seed banking fails to work gave me a greater insight into the way seed banking does work.

Having examined the underpinnings of my data collection technique in theory, in the following section I turn to the practice of data collection itself by setting out and justifying the methodologies employed.

Fieldwork methodology

Through my fieldwork I sought to investigate how seed banking acts as a tool for doing food security in practice. In doing so, I drew heavily upon the theory of actor-network approaches, as outlined in the section above. However, because of the specificities of this project which necessitated the gathering of core tranches of data using techniques other than ethnomethodology, the thesis cannot be regarded as one located purely in the actor-network milieu. My fieldwork aims were to:

- Generate in depth case studies of two seed banks, and gather data on a third supporting study site, each selected to be emblematic of the wider practices within the seed banking milieu, and,
- Locate those three studies within a wider framework which addresses the emergent utilisation practices of banked seed.

The two principal case studies were located in the UK, at the John Innes Centre (JIC) and the Heritage Seed Library (HSL). Following the tenet central to the actor-network approach of “stay[ing] with the trouble” (Law & Singleton, 2012, p. 5), these case studies were assembled using ethnomethodology. This was, in the case of the latter, supplemented with data from interviews enabling access to the practices of specific volunteers. Ethnographic methods were chosen because they enabled close examination of the day to day practices underway at these sites in a way commensurate with similar work in the actor-network milieu.

The additional supporting study, the Svalbard Seed Vault (SSV), was located on Svalbard, an island of Norwegian territory approximately equidistant from mainland Europe and the North Pole. The SSV is referred to in this thesis as a supporting study because it was investigated using only interview material. Typically, as was highlighted in the previous section, research following actor-network approaches favours ethnomethodology. However, interviewing was selected as a research technique in the assembly of this supporting study, first, because the SSV itself is more of a storage vault than an active seed bank and as such there is limited day to day activity to witness; and, second, due to the prohibitive cost of visiting the site and spending a considerable amount of time there. In spite of not being a true case study in the ways typical of the actor-network milieu, through my interviewing practice I sought to access data on materials and practices which would make possible at least broad comparisons between the data from the principal case studies and from the supporting studies.

Though specific cases are examined in the two principal studies and the

additional supporting study, I did not set out to frame them, in the traditional sense, as case studies absolutely representative of the wider setting (as per George & Bennett, 2005; Gerring, 2006). Rather, I followed the thinking around case studies employed by Mol in *The Logic of Care* (2008). For Mol:

[e]xamining a practice is not a matter of collecting suitable examples, but of learning new lessons. Good case studies inspire theory, shape ideas and shift conceptions. They do not lead to conclusions which are universally valid, but neither do they claim to do so. Instead the lessons learnt are quite specific. ... A case study is of wider interest as it becomes part of a trajectory. It offers points of contrast comparison or reference for other sites and situations. It does not tell us what to expect – or do – but it does suggest pertinent questions.

(Mol, 2008, pp. 10–11)

The fieldwork was conceived such that, though it was inevitable that not all parts of the seed banking milieu could be investigated (Law, 2004), the cases examined would, as far as possible given Mol's pronouncements above, be emblematic of the interactions between events and practices found across that broader setting. Central to achieving that was the commitment to a fine grained analysis of those samples chosen. Indeed, when employing such research tools, it is necessary to recognise that, although though the research make take in only a limited number of samples, increasing the sample size due to fear rather than sound justification, what has been termed "the 'it's all happening elsewhere' syndrome" (Lacey, 1976, in Hammersley & Atkinson, 2007, p. 159), is likely only to be detrimental to the research. After all, "the whole point of selecting informants for qualitative investigation is to concentrate on an intensive analysis of a a limited number of cases which represent, or are in

some way tailored to, the central objectives of the research" (Davidson & Layder, 2002, p. 173).

Having outlined my broad approach to fieldwork methodology, the following section describes the three research sites and the reasons for the selection in further detail.

The research sites

The seed bank at the John Innes Centre (JIC)¹³

The John Innes Centre is a research centre which specialises in plant science and microbiology, based on the outskirts of Norwich, in Norfolk, UK. The Centre is an independent organisation, but receives the majority of its research funding from UK and international funding bodies, and also receives strategic funding from the UK government's Biotechnology and Biological Sciences Research Council (BBSRC). Since its inception, the organisation's work has been centred on the practice of cutting edge plant science for use in mainstream agriculture. The organisation has also held, in one form or another, a stock of seeds centred around major crops such as cereals and legumes which have long been made available for use by researchers within the JIC and elsewhere. Today, amongst the research laboratories, the organisation houses a seed store with approximately 600m³ storage capacity with a climate maintained at 1.5 Celsius and 10% relative humidity (JIC).

The JIC was chosen as a case study site because of its position as a central pillar within mainstream plant science research at a UK level and with some considerable international significance too. This position which was bolstered in

¹³ In this thesis, the John Innes Centre research organisation as a whole is termed using its full name, whereas references to the seed bank are made using the acronym JIC.

2012 with changes to the facility's funding regime in which, thanks to it having been awarded National Capability status by the BBSRC, it ceased to have to compete with research programmes for indirect funding through the John Innes Centre as a whole and began instead to be issued with guaranteed annual direct funding from the research council (Ambrose, personal communication; also outlined in Ambrose, 2013). Hence, I deemed the practices underway at the JIC to be emblematic of those more broadly in place within plant genetic resource conservation in the UK and in other countries in which mainstream scientific research takes place in a framework that is part commercial and part publicly funded.

The Heritage Seed Library (HSL)

The HSL is the seed bank associated with Garden Organic. Garden Organic is a charitable organisation based on the outskirts of Coventry who undertake work researching and promoting organic food, largely in the UK but at times linked with international partner organisations too (Garden Organic). Their income is derived primarily from voluntary donations, although commercial activities and research grants play a role in their funding stream too (see Garden Organic, 2012, p. 15). The HSL's key aim is to ensure the conservation and continued public availability of vegetable varieties of interest to amateur growers and allotment holders. Such varieties might be former commercial varieties dropped by seed companies as newer, more profitable, varieties were brought to market, or they might be landraces or heirloom varieties formerly commonly grown by UK gardeners prior to the arrival of formalised plant breeding (Garden Organic).

The HSL was chosen as a case study site because it resides at an interesting boundary point between conventional seed banking practice such as that of the JIC, and unconventional seed banking practice such as seed swaps organised by

groups like Seedy Sunday (Guinness, 2013). On one hand, it echoes seed banking in a conventional sense and operates in a way very similar to formal seed banking protocol, emulating, in an approximate fashion, many of the seed banking practices undertaken by the JIC. Additionally, it has other marks of formality, such as being a registered charity or having HRH Prince Charles as its patron. On the other hand, affiliation with its parent organisation Garden Organic is indicative of a rejection of some aspects of conventional agriculture that an organisation such as the JIC would espouse. Further, this unconventional strand to its existence is recognisable in day to day practice. For example, its seed distribution model has long existed on the edge of legality as a result of legal frameworks to do with official registration and listing of seeds exploited commercially¹⁴. Consequently, I regarded the HSL to be an organisation representative of the slightly counter-cultural strand within seed banking practice.

The Svalbard Seed Vault (SSV)

The SSV is a structure built into the mountainside beneath the permafrost of the island of Svalbard, a Norwegian territory located on the cusp of the Arctic Circle. The facility, which is intended to operate as a back up for the world's genetic resources was opened formally opened in February 2008 (Fowler, 2008a) following the resolution over several of a series of technical, political and financial constraints that emerged during its planning (Qvenild, 2008). The

¹⁴In the EU, it is permitted only to sell seeds which have been officially registered through national seed listing programmes. These programmes are designed for the commercial agriculture market, and as such it is unlikely that many of the varieties would be permitted for sale, even if Garden Organic even were able to afford the fees payable for listing. The HSL gets around this law by operating on a subscription model where members pay an annual fee which entitles them to receive six packets of seed per year without charge. Later in the thesis, in Chapter 7, this issue becomes a key subject of discussion.

SSV operates on two levels. Most obviously, it provides an infrastructure for the safety duplication of seeds from seed banks around the world. However, the SSV is also a driver of political change. In order for its infrastructure to be of utility, agreements had to be negotiated that expedited the international transfer of plant genetic resources (Fowler, 2008b).

Thus, the SSV was chosen as a supporting study because, while its infrastructure echoes that of the other two seed banks, the function it is intended to perform is markedly different. In short, unlike the other two seed banks discussed, the role of the SSV is solely to store seeds with a view to their never being made available to user groups except in cases of severe disruption, such as seed bank destruction due to natural disaster, resulted in the loss of a significant number of accessions. As such, it was evident from the outset that the SSV would play a very different role within the broader framework of seed banking than the previous two case studies, and, further, being a relatively new facility, that role had so far been under-examined in social science research.

Before undertaking my main fieldwork at these sites, I undertook a series of preliminary activities. It is these I turn to in the next section.

Preliminary research activities

The truth within Alexander Pope's line "fools rush in where Angels fear to tread" (2010, p. 35) is so universally recognised the phrase has become incorporated into the popular English lexicon. No research design is final and good fieldwork necessarily requires a high degree of flexibility and responsiveness to the material uncovered on the ground (Maxwell, 2012). That said, given the investment in time as well as money required by an approach largely centred on ethnographic method, I regarded the undertaking of some initial scoping

activity as essential to the planning of my research. Its aim was to prevent unnecessary disruption later due to avoidable hindrances, either practical or intellectual. As such, before beginning my fieldwork in earnest, I supplemented the desk based research already undertaken on two of the intended research sites, the JIC and the HSL, by making visits and undertaking introductory interviews. Because a preliminary visit to the SSV would have been impossible due to cost, and because I wished to interview staff at the SSV when more knowledgeable, I instead visited a similar long term seed banking facility in the UK, Kew's Millennium Seed Bank, where I interviewed its manager and was taken on a tour.

The preliminary research activities had three main outcomes. First, as intended, they provided an opportunity to undertake initial investigations into the research field. My framing of the initial meetings as being a scoping exercise also conferred a useful tactical benefit. Although, by announcing myself to be a postgraduate researcher intending to undertake research in this area I was pleased to have positioned myself as being someone relatively knowledgeable in the field, by stating the purpose of my visit as being a scoping exercise, I was freed in part of the social conventions around researcher knowledge that arrive later in the research. In short, while good ethnography requires the researcher to take on the role of an "acceptable incompetent" (Loftland, 1971, in Hammersley & Atkinson, 2007, p. 79), developing good field relations also depends having an acceptable level of competence too. However, while scoping, I felt able to ask questions about wider issues in seed banking which, had I asked them during my fieldwork, might have been regarded as obvious or elementary. Additionally, I benefited from tours of the seed bank facilities from which I gained useful insights into activities I might witness during ethnographic work. Finally, though conversing informally with research

participants I was able to satisfy myself that these were people with whom an ethnographic research project would work on a social level. In sum, through these preliminary visits I was able to certify that the research framework I had prepared for myself would stand up to

The second outcome was one of improving my ability to gain access to the research sites. Access is neither a given nor a right, rather it is a generous offer of time and resources by research participants. As such, the granting of access is predicated upon research participants' confidence that the researcher is worthy of that expenditure of time and effort (Feldman, Bell, & Berger, 2003). Thus, while I may have taken the opportunity of a scoping visit to risk asking seemingly obvious questions, I also took the time to demonstrate the characteristics of competent and capable researcher. In all visits, I sought to present myself appropriately, as an interested professional in the cases of the JIC and MSB, or as a keen practitioner willing to get his hands dirty in the case of the HSL. During my initial contact I did not enquire about the prospect of longer term fieldwork at any of the sites. However, in follow up emails thanking the participants for their time, in the appropriate cases I raised the subject of further research, setting out my requirements but noting them to be open to negotiation (Feldman et al., 2003, p. 24). I was gratified that both the JIC and HSL, the two sites I had initially selected for the ethnographic part of my fieldwork, were keen to allow me to undertake research in their respective facilities.

Indeed, while some researchers find gaining access to be difficult or problematic (Feldman et al., 2003; Hammersley & Atkinson, 2007, Chapter 3), throughout my research the only difficulties I experienced were that at times participants required a polite prompt to respond to my emails, while others

often had busy diaries and finding mutually suitable meeting times required some shuttling of emails backwards and forwards containing proposals and counter-proposals. In large part, I believe this was due to the relative obscurity of the UK's seed banking and plant genetic resources scene as a whole. In other words, for the most part this is not an "over-researched" (Clark, 2008) group and, rather than being weary of researchers, many in the area were instead keen to see greater awareness being raised of the work undertaken, particularly in the context of a public awareness agenda in funding in conjunction with increasingly scarce availability of financial resources.

Third, the preliminary research allowed me to cement approach to ethical research practice. There is some considerable discussion of the ethics of undertaking social science research (for recent reviews see Israel & Hay, 2006; Love, 2012). In comparison to some studies, the research of this thesis was relatively benign, dealing neither with controversial subjects nor subjugated peoples. That said, I took seriously the ethical implications present in all research, in particular by seeking informed consent from my research participants and, in addition, seeking not to represent my research findings accurately. My research methods gained the approval of the Open University's Ethics Committee. In the preliminary research, I developed my ethical practice as follows. Participants were supplied with an information sheet, usually via email in initial contact and again in hard copy upon first meeting, and were required to sign a document registering their agreement to involvement in the research process (the information sheets, one for ethnography participants and one, slightly modified, for interview participants are found in Appendix 1, along with the signatory sheet). Participants were advised that they were permitted to see the data I held and to require its deletion within a certain time period. Such practice proved to be effective in both alerting research participants of

their rights within the research, and in protecting myself from accusations of bad practice; consequently, they were maintained for the main research phase. On one or two occasions, participants made reference to information that was commercially or scientifically sensitive which they then requested were not referenced in the final thesis. When this occurred, particularly because such information invariably did not contribute to the arguments I was assembling, I was happy to oblige.

Having considered the preliminary work undertaken prior to my main research phase, in the following sections, I shall turn to the research itself.

Undertaking ethnographic work

As noted in the introduction to this section, ethnographic tools have been widely employed by researchers guided by actor-network approaches. However, of course, ethnographic techniques are not obligatory within such a framework. Rather, I employed ethnography as a research tool because it was the tool best suited for the gathering of the type of data I sought; through reading of relevant literature (in particular, Hammersley & Atkinson, 2007), I foresaw that ethnography would facilitate:

- the flexibility and open-endedness (see Maxwell, 2012) necessary to work according to the theoretical tradition of actor-network approaches;
- the ability to engage closely with and over a relatively long time period with my research participants to build up a comprehensive understanding of the organisations studied;
- access to the materiality of experience, both personally and by witnessing the experiences of other, rather than relying on reports about those experiences from interviews or printed documents; and

- access to those day to day practices which interview participants might consider too commonplace to report using interviews or other methodology.

Having decided upon ethnography, and negotiated access in the follow up to my initial scoping visits, I went on to undertake the research itself. In this section, I draw out some key points which emerged during the ethnography phase of the fieldwork.

Degrees and times of immersion in ethnographic research

Ethnography is a mode of research which inevitably entails immersion into the lives of those who it is investigating. However, it is necessary to consider the specifications of that immersion. In many cases, absolute immersion into the world of the research participants may at times be unnecessary. As it has been put frankly elsewhere, "studying a Polynesian village while living in it requires full-time participation; commuting daily to a fire station to study firemen while living at home requires only part-time participation" (Werner and Schoepfle, 1987, in Schensul, Schensul, & LeCompte, 1999, p. 94). Negotiating the level of participation was a key part of my research design.

Once having arranged an agreement in principal to undertake fieldwork at my two ethnographic sites, I then had to resolve the practicalities of my visits. Although both sites were open to my attending when I wished, the "gatekeepers" (Hammersley & Atkinson, 2007, pp. 49–53) at each, who were those in positions of management at either site, suggested particular days of the week which they felt would be the most suitable for my research. In both cases, the suggestions made were sensible and were not, I believe, intended to obfuscate any research findings. Rather they were linked to staff availability

and work to be undertaken. During the first period of research, I made weekly visits, on Wednesdays, to the HSL; and, during the second period of research, I made weekly visits, on Tuesdays and Wednesdays, to the JIC. The HSL had four full time staff. Apart from Wednesdays, when a team of volunteers who ranged in number from three to eight depending on their other commitments, the full time staff were largely based on quiet, desk based, activities. The JIC, who did not have volunteers but did make use of agricultural staff when needed, had a lower core staff count of just two, of whom one, the person whose work I was shadowing, was part time, and the other, in a managerial position, engaged almost solely in desk based research. While I suspected that access to those administrative tasks would have provided additional and useful material for this study, I also suspected that gaining such access would have resulted in too great an imposition to seed bank staff and that material yielded per visit would have been too low, given the limited number of visits possible, to have been a viable long term proposition.

This discussion demonstrates two central disadvantages to the ethnographic method. First, while ethnography is a very good tool to investigate what happens when groups of people work together on a project, it is more difficult use ethnography to understand the work of individuals undertaking cognitive tasks without interrupting excessively. Second, the time consuming nature of ethnography can prove costly when undertaken away from home, a factor which can reduce the number of site visits possible over the research period. To resolve the former, I spoke informally with staff primarily engaged in cognitive work to gain an understanding of that work; and, in the case of the latter, I was required simply to work within the constraints of my budget.

I began the fieldwork phase of my research with the HSL, undertaking visits in

October, November and December. This, in a way fortuitous and quite unplanned – and demonstrative of the agency of the research setting in directing the research practice (Whatmore, 2003) – proved to be an excellent time to visit. Many of the practices under way at seed banks, especially ones with rapid stock turnover in the way of the HSL, are linked to the growing season. As such, my visits in late autumn and early winter allowed me to witness the work of tidying away from the previous growing season and the preparations to be made for the following season. As Martyn Hammersley and Paul Atkinson observe, “the researcher will probably identify particularly salient periods and junctures [in time] ... [and s]uch crucial times should then come in for particular attention” (2007, p. 37). Reflecting upon my unintended good fortune at having arrived on site during a particularly active part of the year led me to think carefully about the most suitable time of year for my visits to the JIC. In communication with staff at the organisation, I arranged for visits around late winter and very early spring, over February and March. Visiting at these times allowed me to witness the preparations for the coming growing season, realising that once the growing season itself was under way, the activity would principally be that of maintaining the outcomes of decisions taken earlier in the year, rather than any new tasks started or new decisions made. I made one follow up visit in June, in order to see how these preparations had developed.

Having examined the arrangements made for my ethnographic work, I now turn to its implementation.

Proximity, embodiment, and helping out at seed banks

“The favoured way of making the most of oneself as a tool of ethnography is to do as others do, to have the same or similar subjective bodily experiences of

being in a particular ethnographic place and time" (Madden, 2010, p. 83).

Raymond Madden exemplifies his discussion with reference to two monographs, in the writing of which, their respective authors took part in the very obviously embodied and physical activities of boxing (Wacquant, 2006) or dance (Alexeyeff, 2009) as a tool to engage with their research participants. While demanding significantly less physical exertion than the studies quoted, I too employed an embodied technique to engage directly in the practices underway in the seed banks I studied. In other words, where practical, I assisted my research participants with seed banking practice.

Such proximity can impede the research process, as Hammersley and Atkinson warn in their study of field roles (2007, pp. 79–89). When the role of researcher is concealed entirely, one can be so distracted with maintaining the pretence that one is unable to undertake any fieldwork. Similarly, even when public about one's researcher status, it is possible for interpersonal relations to disrupt research. This may occur as one's proximity engenders an inability to view the research site from a critical angle, or one's keenness to help leaves one obligated to the running of the site and so unable to step back and do research. Conversely, as Kathleen and Billie DeWalt note, by bringing about a closer interaction with the subject of research than simple observation, such physical engagement improves the quality of the data collected and the analysis of that data (DeWalt & DeWalt, 2011, p. 10).

I found that the formation of a reciprocal arrangement between myself and the research participants facilitated my research, such that it was clear that I was not always in the position of taking from my research participants without having given anything in return. However, aware of the risks of this approach, I ensured that I maintained clarity about my status as a researcher first and

foremost. Ensuring that my research diary was with or near me at all times, acted as a prop to assist in my maintenance of this role, as well as ensuring that I was able to take notes when needed. Although, at times, I felt some awkwardness about the need to step back from participation in order to make notes or undertake observations, doing so politely and, in necessary, ensuring that someone was available to take over my task, meant that this did not cause problems. Because each site was well staffed for the tasks to be done, when I did assist, I was merely a helpful pair of hands rather than an essential team member.

My visits to the HSL coincided with the days volunteers were invited to help with key tasks. Although I was not obligated to assist in the work underway, in the context of other visitors volunteering assistance I would have felt out of place as a passive observer. In addition, engaging with the tasks underway offered a route to questioning activities that seemed to illicit more useful responses; in other words, a question framed as "why are we doing things in this way?" tended to be a more useful prompt, yielding longer and more comprehensive responses with greater opportunities for follow up questions, to "why are *you* doing things in that way?".

Although the JIC does not rely on volunteer labour for its seed banking activities, my being a presence who could help out with routine tasks was welcomed from the outset and again proved invaluable for building a rapport as well as gaining a greater understanding of the practices underway on site. At the JIC, I principally shadowed one of the two key members of staff, the other being employed on primarily desk based administrative activities. My height (I am 188cm), which became a running joke with the staff member I was shadowing who was somewhat shorter, and I was frequently asked to undertake

tasks routine such as retrieving seeds from the higher shelves in the seed bank's cold store. Another task, which similarly relied on my height, was to assist with putting bags over the ears of grain to prevent cross pollination of material being grown out to bulk up seed stocks. Being quite strenuous and invoking a quite considerable pollen allergy, this practice was very memorable for its embodied experience. However, in being so memorable it also provoked some considerable thought, and eventually went on to make up a significant part of the discussion in the empirical section of this thesis.

Conversations, chats, and everything short of interviews

While ethnography is a useful tool to engage with materiality, often in an embodied way, it also facilitates the building of relationships with people. Because the research method intrinsically requires repeated engagements with the same people over a relatively long period, a sociability is developed which can yield much in the way of useful data, which Hammersley and Atkinson term "'naturally occurring' oral accounts" (2007, p. 99). In both the HSL and the JIC, a routine existed where staff would take tea and lunch breaks together, during which conversation would range from topics directly related to work, such as work recently completed or work needing to be done, those with some connection, such as issues surrounding recent work tasks, and those unconnected, by which I mean general conversation. Conversation developed along similar lines, particularly at the HSL, when volunteers were engaged in relatively mundane tasks such as preparing envelopes of seeds to be sent out to members the following spring.

These conversations were of use to me in two ways. In some cases they were a useful opportunity for me to ask questions and clarify details related to my work. Particularly at the JIC, staff set aside time for me to raise issues or

queries that I might have and, occasionally, the informal chats become discussions just short of interviews. Christina Stage and Marifram Mattson discuss this type of oral data gathering as distinct from the normal setting of the formal interview and instead refer to it as a form of "contextualized conversation" which "blur the traditional interview roles within the researcher-participant relationship" (Stage & Mattson, 2003, p. 101). At other times, I chose to stay quiet as conversations developed between staff members. Through these conversations, I was able to glean useful insights I would not have otherwise been able to access simply because, as a newcomer to the research site, I would not have known even to ask. Such insights were key to the development of my understanding of the various issues at hand.

However, at times, these conversations became a distraction. For the sake of good manners, I would find myself trapped in a conversation with a well meaning participant keen to impart information they thought would be useful while I was missing out on practices happening elsewhere. Similarly, because of my interest in practices, because of their abstract nature even the most interesting of these oral accounts felt less valuable than witnessing activity underway. As such, while appreciative of the generosity of participants in taking the time to impart information and explain wider issues, at times I wished that we could just get on with work of seed banking.

Looking at documentation

In the thesis, I employed a mixture of primary and secondary documentary resources (Gibson, 2009, Chapter 5). Beginning with the primary data sources, at both field sites I examined the documentation assembled by the seed banks about the materials that were banked. Each operated a system of data storage through which they recorded information about every one of their accessions,

although the technique employed for doing so differed at each site. I consulted each of their data storage systems, which entailed either examining an online resource in the case of the JIC or looking over a sample of paper files at the HSL. I recorded notes about the type of data stored and the format of its storage, following this up with discussion with seed bank staff. Other primary sources of documentation were also of utility. Employed as evidence in the thesis are the materials from a consultation commissioned by Defra. The consultation sought responses from all interested parties on the subject of a change in legislation to permit the commercialisation of the seeds of heritage varieties. The consultation prompt materials, by which I mean the letter sent to those questioned alongside supporting the documents which set out how the new legislation might operate were freely available from the Defra website; a copy of each response was posted to me following an email request. Furthermore, I made extensive use secondary sources, in particular, publications and briefing papers from governments, international organisations, pressure groups and seed banks, as well as some online resources such as websites.

I collected this data from this documentation in different ways. In the case of seed bank data storage mechanisms, I elected to engage with the material with the intention of getting a sense of it, rather than endeavouring to analyse it in a structured fashion. This was because, rather than intending to ascertain the content of these documents, my interest was in understanding how these documents functioned as actors (Prior, 2008) in the constitution of an informational backdrop to seed banking. As such, I recorded my impressions of these documents in my field diary, and photographed those which I considered useful as demonstrations of my findings. In the case of the other documentary sources, I accumulated the materials in a more traditional fashion by taking

copies, making printouts, or downloading files, with a view to examining them solely for their content.

In the following section, I move on to consider the way I recorded the data collected.

Recording ethnographic data

While, for some researchers, the very act of note taking experience has been reported as a stressful or complicated event, perhaps due to the covert nature of the research or because note taking was regarded by research participants as an invasive or inappropriate activity (Hammersley & Atkinson, 2007, pp. 142–143), I was fortunate that, in the main, at the field sites where my research was based I did not experience such difficulties. At both sites, although this was particularly true of the JIC, participants were personally experienced in and comfortable with scholarly research practice, and as such my presence, field notebook in hand or actually in the process of taking notes, did not cause any particular concern. At the HSL, where I was working with volunteers as well as paid staff members, I did at times detect some slight discomfort around my note taking, particularly if I was seen to be writing busily immediately following a volunteer having asked a question to a staff member, for example. However, I made a point of ensuring transparency, stating that my research notes were available for consultation if participants desired (an offer which was not taken up), and by discussing my research, its progression, and the matters I had found interesting, when asked. As we took tea breaks and lunched together, this proved an invaluable time to have such conversations. Although I was willing to help out with tasks, as noted above, I made it clear that my principal role was of researcher, and thus felt able to duck out of some practical activities to make notes when necessary.

In a way typical to ethnographic research (see Emerson, Fretz, & Shaw, 2011), I routinely recorded my observations as jottings or brief notes in a fieldwork diary, either live, at the time of their experience, or as soon after the event as possible. I later, either that evening or in the days following benefiting from the days between each ethnographic visit, transcribed those notes onto my computer, fleshing out details by replaying key events in my mind and so building up comprehensive outline of my experiences over the course of the fieldwork. I routinely revisited these typewritten field notes over the course of my research phase, adding additional details if they came to mind, making notes, and drawing out links between events witnessed at one site or at one time, and another (see Hammersley & Atkinson, 2007, p. 159). As such, I regarded these as live documents, open for editing throughout the research phase.

In the following section, I turn to consider the second tool for data collection I undertook in the research for this thesis, that of interviewing.

Undertaking interviews

Although, typically, work in the actor-network milieu is based upon ethnomethodology, I employed interviewing as a research technique to gain access to material which, due to the specificities of this study, would have been inaccessible through ethnographic techniques. I used interviewing to complete one of my principal seed bank case studies, building upon the ethnographic data I assembled at the HSL; and interviewing was also employed as the sole data source for the supporting study of the SSV. Additionally, in order to broaden the scope of the project by considering the utilisation of plant genetic resources in fields beyond but closely connected to the seed banking milieu, I

undertook interviews with several carefully selected key informants. (Interview schedules and a list of informants is detailed in Appendix 2). In this section, I briefly introduce interviewing as a research methodology, before going on to outline the specifics of its utilisation in each setting.

Undertaking interviewing as a social science research practice required some considerable planning. As Hilary Arksey and Peter Knight observe, having “read, seen and heard hundreds of interviews in the press, on radio and on television, it is easy to be blasé about them and to assume that interviewing is nothing more than common sense at work” (1999, p. 1). Indeed, avoiding such a blasé attitude was particularly important for me, having been responsible for the production of such interviews in an earlier professional context. As such, I made efforts to prepare for the interview such that I was confident it could garner the results necessary for effective social science research. The two key aspects of this preparation were, first, to ensure that I had prepared an appropriately detailed interview schedule to ensure I covered the areas I required and gathered the data necessary (Rubin & Rubin, 2005, Chapter 7), but, second, readied myself in terms of interview style and technique (Seidman, 2012, Chapter 6) in order to gain accurate, reliable and useable data.

“The more spontaneous the interview procedure, the more likely one is to obtain spontaneous, lively, and unexpected answers from the interviewees” (Kvale, 1996, in Tracy, 2012, p. 139). As such, my research mode was of semi-structured interviews (Gillham, 2005, Chapter 10) which were largely conversational in style. By employing such a technique, I endeavoured to guide the interview in the directions I needed to gain the material necessary for my research, while simultaneously allowing participants a high level of control in

the way they set out their responses so that I did not overdetermine their responses and thus fail to access useful data. Because the interviews I undertook were in a range of scenarios and intended to yield a diversity of different responses, there is no standard interview schedule. However, while discussing each scenario in which interviews were employed, I attend to the schedule employed. Each interview was recorded and transcribed verbatim.

In the sections which follow I outline exactly how I made use of interview research in this thesis.

Using interviews to study the SSV

The SSV, as a supporting study, was the only one for which the data collected was drawn solely from interview material supported by some desk based research. Two key factors affected my decision to employ such a technique. The first was expense. The SSV itself is located in Svalbard, a remote and almost unpopulated island just within the Arctic Circle and its administrative management is based in the offices of NordGen, the Nordic Genetic Resources Centre, which are located in Alnarp, Sweden. Accessing either, or both, sites would have been very costly and, this being second point, would likely not have been good value for money in terms of data yielded. This is because the structure by which the SSV works is so distributed, I would not have gained access to any additional sources that could not have been achieved using the interviewing methodology I chose to employ.

Through the interviews I sought to gain an approximation of the kind of data which I realised through my ethnographic work at the JIC and HSL. In short, my two aims were to attain an understanding of the workings of the organisation at large, and to attempt to engage with the materials and

practices of seed banking at the SSV. As such, having approached him via his secretary and received his agreement, I undertook two lengthy interviews with Cary Fowler, who is a central figurehead for, and may be regarded as having a *de facto* headship of, the SSV. I also interviewed Simon Jeppson, who I approached following the suggestion from Cary Fowler and who, as the Seed Store Officer, was responsible for the management of the SSV in a practical sense, the banking, cataloguing, and, if necessary, removal, of material from the Vault itself. Outlined in Appendix 2 are the key themes I discussed with each participant.

These interviews were undertaken using Skype. There is literature emerging around using online technology in social science research (Evans, 2008; Kazmer & Xie, 2008). While some recent work has focussed on the benefits of telephone interviews in preference to face-to-face meetings (Holt, 2010), I found that Skype was preferable largely because of its fairly effective emulation of the face-to-face setting with video cameras activated, giving both the researcher and the participant the opportunity to more accurately and comfortably respond to social cues in ways more reminiscent of ordinary conversation (Hanna, 2012, p. 241). That said, the success of my use of Skype as a means for interviewing should not be regarded as evidence of its universality. Both I and the research participants were confident Skype users, comfortable with the technology from both practical and social perspectives.

I now turn to the second situation in which I utilised interview material.

Using interviews to support research at the HSL

Although the majority of the work undertaken at the HSL was based on ethnographic method, one particular practice of interest which the organisation

deployed was inaccessible through this method. As outlined in the organisation's profile above, the seed bank delivers seeds to its members annually. These seeds are derived from a number of sources including some being produced on site and others, those of more fragile varieties, by contracted growers based in more reliable climates in southern France. However, the majority of seeds sent to members are produced by seed guardians, other HSL members who voluntarily take on the role of bulking up the stocks of particular varieties. Because this work takes place away from the main HSL site and in the domestic gardens or allotments of the guardians themselves, and takes place over an annual growing cycle, utilisation of observational methods to investigate this practice would have been impossible. Therefore, in order not to leave it unexplored, I employed interviewing.

The HSL generously acted as a gatekeeper in this scenario, examining their membership records for members close to London or Milton Keynes and sending on my behalf a letter requesting that they be involved in the research. I received six replies, of whom, three eventually became research participants. With those three participants I undertook two interviews, one at the beginning of the growing seasons and another at its close. Each interview was made up of two components, a traditional semi-structured interview and a site visit to the location in which the seeds were grown out, in order that matters of importance to either myself or the participant could be examined again in material context. The broad interview schedule, detailed in Appendix 2, was followed.

I now turn to the final situation in which I utilised interview material.

Using interviews to broaden the study

Once having produced my two seed bank case studies and one supporting

study, and taken the time to reflect upon them, I felt there to be a need to broaden the study. Specifically, I realised that in order to better grasp the way seed banking was conceptualised as having particular links to food security, I needed to examine the way that materials from seed banks were employed in food security settings. Somewhat dishearteningly, from desk based research, although general allusions to the importance of preserving seeds in seed banks for food security could be found, details about utilisation were scant.

A report on the BBC programme *Farming Today* (2011) in February 2011, which I came across as an email recipient of the Soil Association's daily media digests¹⁵, significantly changed the fieldwork landscape in this regard. The programme reported on the announcement of a £7 million multi-institution funding award by the BBSRC stating that some researchers would be "using traits from ancient varieties of wheat and other cereals to breed modern strains which could produce more food without harming the environment" (Weatherill, 2011). I made contact with Professor Graham Moore, the project leader interviewed on the broadcast, who directed me to Dr. Simon Griffiths, a scientist at the John Innes Centre and the leader of the strand of the research programme focussed specifically on isolating useful traits from those old grain varieties, who agreed to be interviewed with his colleague Simon Orford. Through some considerable online searching, I also came across and made contact with Dr. Thomas Döring, a geneticist at the Organic Research Centre whose work, though wholly disconnected to the BBSRC award, was also centred on making use of old grain varieties. I also spoke with Phil Sumption of Garden Organic, who had been working on a project in conjunction with partners in both the organic and conventional sector to isolate traits of potential utility

¹⁵ I had been signed up by a colleague in the organisation's press office some years previously, although the digest is also available online at <https://www.soilassociation.org/supportus/readtodaysnews>

within the HSL's collections of leafy vegetables. An interview schedule was prepared, which enabled me to access the details of these three projects in ways which made them comparable, but which was broad enough allow for deviation into unexpected topic areas reflecting the paucity of details of such research projects in the public domain. This is outlined in Appendix 2.

The cutting edge nature of this research, which I had been alerted to in my interview with Simon Griffiths and Simon Orford, was demonstrated when I sought to investigate the extent to which such work was finding a place in current plant breeding practice. I undertook exploratory interviews with two significant, or even elite (Parry, 1998), figures within the plant breeding and food security setting. They were, Penny Maplestone, Chief Executive of the British Society of Plant Breeders Ltd and Professor Martin Parry, Head of Plant Science at Rothamsted Research. In sum, although both spoke very favourably of the general importance of seed banking, the preservation of plant genetic resources, and the possibilities that it could have for agriculture in the future, neither could foresee its use in agricultural practice on the commercial timescales they worked with.

Having provided a comprehensive examination of the work undertaken to obtain the data for this thesis, I now turn to the tools employed in the examination of that data.

Data analysis

At the completion of my fieldwork period, I had a wealth of almost exclusively textual data made up of transcriptions of ethnographic field diary notes, the field diaries themselves, verbatim transcriptions of interview material, and a

series of documents. I also took a small number photographs¹⁶ at my field sites which served as *aide-mémoires*, reminding me of features such as layout, scale, or other physical characteristics in order to assist in the interpretation of the textual notes. In other words, I had a "mess" of data (Law, 2004). In this section, I account for the way the material I collected was interpreted and analysed in the drawing of conclusions from that mess.

Debates exist around the notion of "triangulation", by which I mean the integration of results, in research that has employed a mixture of methods (Hammersley, 2008). While this thesis is not based solely on one research method, the similarity between each method used, all generating qualitative and text based data, is such that much of the sources of that controversy have been evaded; I have not, for example, mixed qualitative and quantitative methods, nor have I employed one method as a tool for verifying another (these being two key concerns that Hammersley, 2008, raises). Rather, my use of mixed methods, and my efforts to integrate and draw conclusions based upon the various results gained between each technique, is best described in these terms:

The use of different methods to investigate a certain domain of social

16 Although the images reproduced in this thesis were taken with a digital SLR, the majority of *aide-mémoire* images were taken with a camera phone. It has been argued that camera phones have altered the way image making functions in social practice (Gye, 2007). Though my use of a camera phone to collect images was too infrequent to fully construct the argument in this thesis, I suspect that there is an argument to be made around the role of camera phones in ethnographic fieldwork which hinges on the combination of the ease of taking pictures with mobile phone cameras, coupled with the social acceptability of doing so (I certainly found people more willing to be pictured on a mobile than on an SLR; I also found that taking detailed photographs, such as of hands manipulating seeds, to be regarded as less unusual with a phone than with an SLR).

reality can be compared with the examination of a physical object from two different viewpoints or angles. Both viewpoints provide different pictures of this object that might not be useful to validate each other but that might yield a fuller and more complete picture of the phenomenon concerned if brought together.

(Erzberger & Kelle, 2003, p. 461)

As such, I was confident that undertaking my data analysis would not be made more complicated by a need to assimilate findings from vastly different sources into one series of arguments. That said, the making of data into arguments remains a complicated process, and I agree with the approach called for by Mike Crang, in which he argues that "[i]t is better to think that through analysis we make interpretations, not find answers" (2003, p. 127). This distinction is important, and, furthermore, it fits with the arguments made earlier in the chapter about undertaking research within an actor-network framework. In short, rather than research acting, as Law has put it, like "a methodological version of auditing" (2004, p. 6), Crang's contention that we "*make* interpretations" (2003, p. 127, emphasis added) chimes with the assertion that knowledge is produced as an outcome of the observation and telling of events brought about through the work of agentic human and nonhuman actors (Law, 2004; Venturini, 2010; Whatmore, 2003). The arguments or conclusions drawn from work come from a practice of analysis that is best understood as a practice of "disciplining our material, of creating order from our work and sustaining that order" (Crang, 2003, p. 128).

Indeed, while the notion of a distinct analysis phase is not an absolute fallacy (of course, there is a period where one is no longer collecting data but one has yet to begin writing up), but data analysis also occurs before and after that

phase. Law describes how, by ceasing to tape record meetings and instead take notes, he adjusted his fieldwork practice in a way which consciously Othered, or excluded, a significant amount of possible data. However, his decision to do so was in fact centred on a desire to hone in on specific details of interest without being distracted by the broader “dazzle” (Law, 2004, p. 108). Put differently, analysis undertaken in the collection phase was used to adjust the way he continued to collect data. Similar adjustments to fieldwork practice as a result of early data analysis took place in my own research. First, as I began to recognise which practices were key seed banking practices (as opposed to ones which were less important, or were undertaken in response to an unusual or less significant scenario), I learned to focus my data collection on these practices. This was of particular benefit at the HSL where, because of a reliance on manual volunteer labour rather than automation for example, significant amounts of time were spent undertaking fairly mundane tasks such as packing seeds into envelopes. In that case, for example, I found that the more interesting practice was the administration of that seed packing because it spoke to themes identified elsewhere in the fieldwork. Accordingly, I made use of my time enquiring about that administration.

Once I had completed my fieldwork, I began the conventional data analysis period. The data from my ethnographic work formed the core of the thesis and, as such, dominated my data analysis activity. Though I disagree with the argument that the possibility of ethnographic data analysis in any formal sense is “myth” (Scott-Jones & Watt, 2010), my experience has led me to concur with the pronouncements of Hammersley and Atkinson who warn that “it is important to recognize that there is no formula or recipe for the analysis of ethnographic data. There are certainly no procedures that will guarantee success” (2007, p. 158). That said, there are evidently some activities which

make drawing sound conclusions from ethnographic data more likely, the most important being a closeness with the data resulting from "[d]etailed and repeated readings" (Hammersley & Atkinson, 2007, p. 162). Preferring the physicality and tactility of textual data on paper as opposed to on screen, rather than employing data analysis software I instead, at the end of my fieldwork phase, printed double spaced and widely margined hard copies of my field notes and interview transcripts and set about digesting them. As Julie Scott Jones and Sal Watt suggest, "[d]ata analysis should be seen as a two-stage process" in which the first stage entails the "ordering, collating and managing" of data to make its analysis possible, and the second stage "involves actual data analysis" (2010, p. 159).

Thus, I began by reading through the data, taking notes on my print outs, in my research diary, or on sheets of scrap paper, with a view to "seek[ing] relationships across the whole corpus" (Hammersley & Atkinson, 2007, p. 163). My aim was twofold, first to draw out a lateral story which outlined how material came into seed banks, what happened to it while it was banked, and the ways it might later leave; and, second, to draw out the key themes within that lateral story which united the various different versions of seed banking. The claims later made in the chapters were underpinned by these themes: the way seeds are practiced in seed bank settings as they enter the seed banking milieu, and become included in it through regeneration and data management; the temporalities of seed banking; and, finally, the politics of seed banking.

Rather than employing a highly mechanised processual approach to my data interpretation, as favoured by some authors (such as Grbich, 2012, Chapter 4), I employed a less structured technique. Returning to the method assemblage approach (Law, 2004), I tentatively experimented with concepts which seemed

to help make sense of the mass of data, sculpting them and experimenting with their boundaries, before dropping some and taking others on. For example, the way coherent varieties are foregrounded in some seed bank settings versus the primacy of genetic variation at others, which became known as “variety / variation” in my notes, were developed but not eventually included in the final thesis. Rather, the process of making interpretations was as iterative as that of defining research questions, and while the “variety / variation” concept did not become a core part of the thesis, the ideas which developed around the concept became incorporated in the concepts that were included.

Various approaches were used the analysis of the documents assembled. The significant majority of those sourced were conventional publications from interested organisations such as pressure groups or policy and scientific advisors. These documents were analysed in the same way as would be an academic text, and were used in the construction of my own understanding of the milieu at large and cited in the literature review chapters. Where documents were used as evidence, in the case of the data assembled around Defra's heritage seed commercialisation consultation, they were analysed in a similar way to that of ethnographic material or interviews; a practice of close reading followed by the assembly of ideas thematically. Finally, the documentation used in informational practices at seed banks was analysed in a way which took into account the practicing of that documentation as much as the content itself. In this way, I regarded them as “documents in action”, and, as such, paid attention to the way “documents as ‘things’ function in schemes of social activity” (Prior, 2008, p. 826). Therefore, in my examination of them, as well as attending to the way they had been made, I attended to the way that they were themselves agents acting to make the materials about which they written.

Indeed, materiality and material agency was central to the analysis of almost all of my data and, consequently, ensuring this was properly represented in the interpretations I made was crucial. Doing so effectively was not a matter of undertaking a specific practice during the data analysis process, rather it was an outcome of having successfully investigated the role of the material throughout the research process such that the human and nonhuman associations were accurately detailed in the field notes. From that point, the greatest challenge was the lexical one of how to write about the material and human assemblages identified without accidentally, for example, employing an anthropomorphic vocabulary. As such, the analysis of findings did not cease at the end of my formal analysis phase. "Writing is ... closely related to analysis" (Hammersley & Atkinson, 2007, p. 191). As I have already indicated in this chapter, I found it impossible to separate the practice of research into a series of discrete sections, instead moving backwards and forwards between research design and research practice. As such, I regarded the act of writing up itself as a final tool for analysing my data. It was only by the planning and eventual creation of the chapters which follow which I finally felt certain of the conclusions that I had come to.

Conclusion

In this chapter, I have undertaken three key tasks. First, I examined the theory of methodology located in the actor-network milieu; second, I outlined the research methods I practiced, justifying my choice of specific techniques and highlighting their limitations where appropriate; third, I set out how I analysed the data generated and used it to make interpretations.

Although it is wrong to assume the actor-network approach is itself to be a methodology – as Mol argues, one cannot "use ANT" (2010, p. 261) – as I have

argued in this chapter, there is a set of distinct methodological tools which may be employed in order to produce work which responds to the theoretical lessons of that approach. This is because the aim of the actor-network milieu is to engage with and understand practices or events. As such, and related to the movement's origins in ethnomethodology, an observational research practice tends to be favoured. In this chapter, I have summed this up in the statement by Latour "just look at controversies and tell what you see" (cited in Venturini, 2010, p. 259). Furthermore, and drawing from a similar theoretical vein, the research methodology was underpinned by a conviction of the need to wrestle with the "mess" of social science research (Law, 2004). Consequently, rather than seeing method as an auditing process to discover answers about the world, I have used this chapter to argue in favour of the method assemblage approach. Thus, I contended, the outcome of the fieldwork of this thesis was a series of conclusions constructed from that which was made present by my research.

It was drawing from these pronouncements that my fieldwork was undertaken. Employing a largely ethnographic approach, supported by interviews and documentary analysis, I assembled two seed bank case studies and a supporting study. Additionally, I explored the wider setting of seed banking, looking at the utilisation of banked seed. I drew this data together, analysing it in such a way that I "condensed and amplified" (Law, 2004, p. 117) the realities found into the arguments I went on to construct. In the chapter which follows, I turn to the first of those arguments, exploring how seeds, through being implicated into the practices of seed banking, become plant genetic resources.

Chapter 5: Seeds in practice

Introduction

In this chapter, I examine the way seeds are worked upon in seed bank settings. I do so because, I argue, it is by this work that seeds are made into, what are termed in the field, plant genetic resources; furthermore, as I also argue, it is only by becoming plant genetic resources that seeds are able to become the materials of food security. Central to the making of these arguments are two contentions which are developed over the course of this chapter. Each of these are rooted in theoretical conversations about materiality, first examined in Chapter 3. These contentions are, that objects come into being due to practice (Law & Mol, 2008a; see Law, 2002; Mol, 2002), and, as a result of this practice, that objects may be multiple (Mol, 2002). In the remainder of this introductory section, I set out the way each of these contentions is developed in this chapter, and then signpost the route I follow in presenting this argument.

Mol has stated that “[t]he new talk about what is does not bracket the practicalities involved in enacting reality. It keeps them present” (2002, p. 54). In other words, to fully understand what something is, one must examine what is done to it, and by it, that makes it so. Within the nomenclature of seed banking is the implication that these facilities are little more than inert storage vessels. But, as demonstrated in the literature examined in Chapter 2, this is not so; they are facilities within organisations with – amongst other things – cultures, histories, and employees. What is more, seed banking is about work, and this work is undertaken in both the storage of seeds, and in their

distribution to users. While the work involved in the movement of materials from place to place might appear more immediately obvious, as I shall demonstrate in this chapter, there is activity and practice in the work of storage too. As such, I argue, that what seeds are made into, in being materials stored in seed banks, is an outcome of an amalgam of all these practices: seeds become plant genetic resources because of the various ways they are practiced in a seed bank milieu.

Paying attention to practices, inevitably reveals their diversity. Across time and space, objects are practiced in numerous different ways. However, this diversity does not mean that each different set of practices must be understood as bringing about a discrete object. Rather, there is coordination between these practices which enables objects to hold together coherently (Mol, 2002). In contrast to plurality, the notion that there exist different types of a similar thing, this coordination work brings about multiplicity, a state in which an object is said to be "more than one – but less than many" (Mol, 2002, p. 55). The object referred to in this chapter is that of plant genetic resources. As noted in Chapters 1 and 4, this thesis is centred around research at three quite different seed banks. However, by demonstrating, as I do in this chapter, that each seed bank engages in slightly different practices to make seeds into plant genetic resources, I do not argue that several different versions of plant genetic resources are brought into being. Instead, I argue that the concept of plant genetic resources is multiple. Although the practices may be different, the outcomes they seek to achieve through those practices are coherent.

These ideas are explored empirically in three sections, each of which examines the range of practices employed in a distinct phase of the making of plant genetic resources. In the first section, I consider the way that seeds enter into

the plant genetic resources milieu by their being incorporated into seed bank stock. I then turn to two of the ongoing phases which act to maintain the status of those seeds as plant genetic resources, the first being the regeneration of the resource material and, the second, being the creation of an informational landscape into which the material is embedded. I now turn to look at the first of those phases.

Entering the plant genetic resources milieu

I begin my examination of the making of seeds into plant genetic resources by investigating their arrival in the seed banking milieu. Critically, I argue that a boundary point must be traversed in which seeds cease to be objects in their generic sense and become, instead, the objects of plant genetic resources. Entry into the seed banking milieu marks the passing of this boundary point, after which seeds become plant genetic resources and, hence, are able to function within food security settings. Of course, that boundary is flexible, and materials may move in and out of the category of plant genetic resources depending on the way they are practiced. However, because there are such profound implications to being a plant genetic resource, implications which affect how those materials are used by practitioners in food security related fields and elsewhere, the recognition and exploration of that boundary and its significance is essential. This is particularly so because, in spite of its importance, there is little or nothing that can be discerned either from visual examination or through closer testing or analysis to distinguish between a seed that is enmeshed in, or one outside of, a plant genetic resources framework. In short, becoming a plant genetic resource is the outcome solely of practice, and not of material change.

Yet, the practices by which this plant genetic resources boundary point is

enacted differ between seed banks. And, relatedly, being brought into the framework of plant genetic resources at one site or in one organisation might not necessarily mean that the same sample would be conferred plant genetic resource status at another. The observance of this fact makes up the first part of a wider evidence base for the status of plant genetic resources as multiple (see Mol, 2002). To illustrate this multiplicity in practice, I shall briefly outline the different routes by which material traverses the boundary point and so becomes a plant genetic resource, first looking at receipt of new material at the HSL and SSV, and then at the generation of new material at the JIC.

Receipt of new material

Of the three, the HSL and the SSV are the most active recipients of new material, or accessions, as they are termed. An accession is a sample of seeds, all of which are of the same variety within a plant species. The sample size in each accession is usually a function of volume rather than number of seeds, as samples are generally required to fit into an envelope in all but exceptional cases no larger than A4 size, and very commonly considerably smaller (see Appendix 3, Figure 1). Because of the need to insure against the risk of germination failure in individual seeds and, where applicable, to make available a representative genetic spread within a variety, samples tend to contain a minimum of thirty to forty seeds. However, this number is greatly increased for varieties which are in high demand from researchers or breeders.

Accessions are derived in very different ways depending on the organisation. At the HSL, accessions come primarily from one of two sources. They are either donated by HSL members, or they are obtained from seed companies who have decided either to cease distributing a particular variety due to it being superseded by a more commercially viable alternative, or who have ceased

trading altogether. The HSL, as a consequence of its limited funding, has two rules which dictate what may be conferred entry to its stock. First, it maintains and distributes only the seeds of heritage type varieties; and, second, these varieties must not be publicly available through any alternative source.

As a conversation with HSL staff member Vicki Cooke revealed, one way by which the library undertakes its commitment to ensure the consistent public availability of heritage varieties is by monitoring the National Seed Lists. These are the lists of varieties commercially available as seed from mainstream vendors. Should the maintainer, the person or organisation who acts as the vendor of seed of the variety in question, decide to cease selling it, they are obliged to give two years notice of doing so through the National Seed List. This is so that another maintainer may step forward and take that variety on if they wish to. If no new maintainer makes themselves known, and the variety is of interest to growers of heritage vegetables, the HSL will adopt it. They will do this in an informal way, by which I mean, doing it without registering their holding of the variety on the National Seed List, nor maintaining the variety in the technically complex ways that such registration requires. Through this route, the total number of varieties on the HSL's files increase by what Cooke estimates to be around fifteen per year, as appropriate heritage type varieties are migrated into the organisation's stock (Research Diary, 3 November 2010).

The HSL also obtains new accessions in large numbers, often quite unpredictably, when seed companies go out of business. In their collection, they already have the seeds of one such large donation on hold in pre-accession status. This means the seeds are in the HSL's seed store but have yet to be characterised or bulked in order that they can be incorporated into the annual catalogue. During the period of my ethnographic work, the organisation seemed

likely to be on the cusp of gaining another. Staff were in negotiation with a company specialising in heritage varieties. Its owner was winding down the business as a result of its relatively low profitability and his age, and intended to transfer his stock to the HSL (Research Diary, 3 November 2010).

As noted above, strict rules outline what is and is not accepted by the HSL. As well as specialising in heritage seeds that exist outside of mainstream distribution channels, the HSL also limits its work to varieties which have a demonstrable connection to the UK¹⁷. Seeds, Cooke recalls, are often donated by the organisation's well meaning members who have found unusual vegetables in local markets while on holiday. While member donations are usually welcomed, these kinds of seed would not make the HSL's stock. Rather, members who donate seeds of varieties which have been grown by, say, family or friends for some time and perhaps with them carry an interesting narrative or history (like the crimson flowered broad bean variety, which will receive discussion later in the chapter) are more likely candidates (Research Diary, 3 November 2010).

The SSV too has an active new accession policy, although their role is rather different to both the HSL's and the JIC's. Rather than holding collections in order that they may be made accessible to colleagues within that organisation or to external user groups, the SSV's collections exist solely as a safety

¹⁷A demonstrable connection to the UK does not mean the variety must be of UK origins or be a UK native. Indeed, given the extent to which food plants have been migrated around the world in the past few centuries, such a regulation would result in the HSL being limited to very few varieties. Rather, in making this rule, the HSL are seeking to ensure that the material they conserve and distribute are relevant to their user groups. Indeed, the HSL has made efforts to source seeds new to the UK grown by people who have migrated to the country through their Sowing New Seed project, coordinated by Anton Rosenfeld (Research Diary, 20 October 2010).

duplicate or back up of material held by major seed banks the world over.

Simon Jeppson, who was at the time acting Seed Store Manager for the SSV, elaborates on the seed bank's conditions of storage:

I must also stress the- I mean, it's not our material- it's just a safety duplicate. First of all the material has to be in an ordinary gene bank or an institute, and they should also have a duplicate in an other gene bank or another institution prior to sending the material to Svalbard. And all the material is under black box conditions. So it's only the depositor who can claim any rights to the material.

(Simon Jeppson, interview, 21 September 2011)

While the SSV has gained a popular reputation as a back up facility preparing for apocalyptic scenarios, likely as a consequence of media reporting (see Pearce, 2007, thought to contain the first reference to SSV as the "doomsday vault"), bolstered by dramatic images (see Appendix 3, Figure 2), the reality is somewhat more everyday. Dr. Cary Fowler, then Executive Director of the Global Crop Diversity Trust, which is one of the three institutions which manages the SSV, explains the purpose of its backing up regime:

We never designed it for the apocalypse. Again, if one were to look at all our planning documents, the words doomsday, apocalypse, et cetera et cetera, they don't occur a single time. We never were thinking about that, not at all. For obvious reasons our day to day experience is not about apocalypse, it's about problems in the individual gene banks. So what we were trying to do was provide an insurance policy for individual gene banks. ... But you know, I do have to admit, but if there were some type of, let's say, regional catastrophe, that affected one area or region

of the world, i.e. multiple gene banks then of course the seed vault comes in very handy. But we weren't anticipating that kind of thing, we were really trying to guard against the problems, catastrophes if you will, that strike individual gene banks. And what I've called the steady drip drip drip of extinction in the normal gene banks. Even the best run gene banks will every once in a while lose something. And that's what we wanted to guard against.

(Fowler, interview, 8 November 2011)

Rather than being a preparation for global catastrophe, the SSV's intended role is one of protecting against loss as a consequence of local error.

SSV rules state that a variety must be held in both its original gene bank and backed up in one further mainstream or surface level gene bank before it may be deposited in their vaults. Thus, to be a plant genetic resource in their version of the term, the material to be deposited must already have become a plant genetic resource in at least two other organisational frameworks. These conditions can be challenging, particularly for smaller and less well funded gene banks. But the Global Crop Diversity Trust is working to ensure the comprehensive safety duplication of as much of the world's plant genetic resources as possible. As such, the Trust has an active programme of searching out potential new members and assisting them through the technical, institutional and financial hurdles needed to back up their stock at another mainstream seed bank and so make them eligible to deposit their stocks in the SSV (Fowler, interview, 8 November 2011).

Generating new material

I turn, finally, to the JIC where receipt of new accessions is currently a less

common occurrence. That said, historically, the organisation would have regularly received new material. This would have come either from organised research trips which aimed to harvest a breadth of material from a specific area, or informal sources such as the requests once made to government officials overseas to return seeds found in markets and the like to UK based collectors (Green, 1987). In its specialist areas of grains and peas, the JIC already has a comprehensive collection of historic material, and, as a result, collection of new material is not deemed necessary. So, as my ethnographic work revealed, at present the bulk of new material that enters the JIC's collections is that created as the outcome of experimental work undertaken by researchers within the organisation's plant science departments.

There are two main sources. The first is mutagenesis programmes, these being programmes in which genetic mutations are intentionally introduced using chemicals or radiation into a sample of a variety from existing stock in order to develop new variation which may exhibit agronomically useful traits. The second is the creation of mapping populations of precise genetic stocks (Research Diary, 9 February 2011). These are the a series of seed samples created by the deliberate crossing of elite lines to produce a population which researchers use to identify the way traits expressed in the phenotype, the plant itself, are expressed in the genotype, or the genes of the plant. An example of this is a mapping population created by the crossing of wheat varieties Avalon and Cadenza produced by the Wheat Genetic Improvement Network in the early 2000s (WGIN, 2009). Such seeds are conserved in order that they may be used in future research work.

Plant genetic resources multiple

Seeds become plant genetic resources by their incorporation into seed bank

settings. In other words, it is this practice which marks what I have termed the boundary point between seed material having the status of a plant genetic resource or not having that status. However, though the term plant genetic resources is used by practitioners across the seed banking milieu, what I have demonstrated in this section is the difference in the ways that plant genetic resources are practiced into being. These versions of plant genetic resource might not necessarily be compatible in every case. In other words, there are multiple versions of plant genetic resources.

For example, though both termed plant genetic resources by their respective seed banks, the precise genetic stocks that make up the mainstay of the JIC's collections would certainly not be deposited in the HSL's cold store. Likewise, while the SSV demands that the accessions they store is duplicated elsewhere, the HSL, by contrast, would regard duplication as a reason to reject a new accession. That said, this is not indicative of a complete lack of parallels between the plant genetic resource materials of different organisations; this is multiplicity not plurality. For instance, materials from a United States organisation similar to the HSL called the Seed Savers Exchange are banked in the SSV. Similarly, when grown out, the JIC's heritage wheat varieties would not be out of place alongside the historic vegetable varieties that are the mainstay of the HSL's collections¹⁸.

These parallels extend beyond the material and into practice, to which I now turn. For although incorporation into a seed banking regime marks the boundary point at which different versions of plant genetic resources come into

¹⁸ In spite of these examples, there is a relative paucity of parallels between the different seed banking milieus in this thesis. However, this is a reflection of the research methodology in which seed banks with very different characteristics were intentionally chosen, as discussed in Chapter 4.

being, this is not where it ends. For material to stay beyond this boundary point requires work too. Seed banking is an ongoing and active process, it is something continually happening in practice as seed banks undergo the everyday routines by which they maintain their banked material. What is more, I argue that these practices act as a central part of the coordination work required to hold the multiplicity of plant genetic resources together coherently. Though undertaken according to different protocol at different sites or in different organisations, these coordinating practices are common to all versions of plant genetic resource making. In the following section, I turn to my first example, the practice of stock regeneration.

Regenerating stock

Seed bank material is not immutable, it will not last forever. Whether to counter the effects of an accessions' reduction in viability over time, or to replace materials removed for utilisation by seed bank user groups, a key banking practice of plant genetic resource making is one of replacing or renewing stock. Quite simply, materials cannot be said to be plant genetic resources if they are not available in a seed banks in sufficient quantities to satisfy requests from their user groups, or, if that material which is extant in seed banks is so unviable that insufficient or poor quality plant are grown from it. In this section, I will discuss two versions of the practice of renewing seed bank stock, one undertaken at the JIC, and the other at the HSL. Before doing so, I shall briefly set out why the situation at the SSV is somewhat different.

Stock management at the SSV

Due to the SSV's role as a duplication storage facility rather than an active seed bank, it does not directly engage with the materials it holds. As such, materials are not distributed directly to user groups from this seed bank, and nor is the

seed bank responsible for stock regeneration should it be necessary. However, some portions of its management practice are adjusted to take into account the necessity of stock regeneration. In particular, SSV staff work with parent organisations to ensure that accessions are boxed together in such a way that those varieties with shorter viability may be removed and regenerated together; although it will be accessions' parent organisations which will be responsible for the task itself when the need arises. Because of the storage conditions of the SSV, most varieties are expected to maintain their viability for at least several decades. The following interview excerpt between myself and Jeppson illustrates this point:

OZ: Is that what you guys are working on, that seeds aren't going to be replaced within the lifetimes of anyone working there?

SJ: I mean, theoretical models are all very beautiful, but we do know that they are not very correct. As I said earlier, barley would by [sic] theory survive for 4,500 years, but when we do our viability management, we can see that models are not very precise. So if you look at [inaudible, a named seed bank] in Germany for example, I believe that they try to rejuvenate their material every ten years, which is very extreme, but we're aiming at every hundred years or so. But then again, it's different from different species. Some of them are very persistent. But, for example allium, onion I believe it is in English, they're quite short lived. So it varies from species to species. But gene banks are aware of this, and thus you only keep one kind of material in one box, for that sake actually.

OZ: So they're [seed banks who have deposited material at the SSV] expecting for something like onions they might be expecting to regenerate it every fifteen to twenty years, but they'll be happy to leave

their barley for their grandchildren to sort out?

SJ: Yeah, that's one of the main purposes for separating material.

(Jeppson, interview, 21 September 2011)

However, because they operate in a more conventional fashion of shorter time scales and direct relationships with their user groups, the same is not true of either the JIC or the HSL, the former of which I now turn to.

Stock regeneration at the JIC

I open the main discussion with an illustration of stock being grown out for regeneration at the JIC. This illustrative material is assembled from the field of from several visits to the JIC over the course of my research, and discusses in detail the practice of seed stock regeneration at the facility. Although the illustration refers to a specific situation, the practices of regeneration discussed are general. The narrative opens in early February 2011.

When I arrive on my first visit, I am introduced to Liz Sayers, one of the seed store's three permanent staff and the person who is responsible for the majority of the day to day running of the facility. She is sitting at a work bench in the building's main room. In front of her are numerous open packets of seed. They are in various tatty looking padded envelopes of uneven size and shape, each labelled in a neat script. Sayers pours a sample of seeds from an envelope, probably around twenty or thirty, and sorts through them. Picking them up using tweezers, she examines each seed carefully. Those she deems suitable, by which I mean those of a good size and which do not exhibit signs of damage or decomposition, she places into a large petri dish lined with moistened filter paper. When the petri dish has ten seeds evenly spread within it, she closes the lid,

labels it with the variety name and accession number copied from the envelope, and puts it aside before selecting another bag of seed and repeating the process. I ask her what she's doing and she explains.

The seed she is working with, a mixture of grain types and varieties, have been in the collection since they were deposited by a JIC researcher in the 1970s. In common with other seed banks, the seeds stored, which are known as accessions, are routinely renewed to ensure their viability. Although there are stories both anecdotal and proven of seeds which have survived a very long time – perhaps decades or even centuries, as Sayers observes, even when stored in the optimal conditions of low temperature and low humidity created in a seed bank, reliable seed viability, a state where they can be almost guaranteed to produce a plant, lasts for a few years or decades at most. Seeds are living things, and although seed bank conditions reduce the already very slow rate, they do still metabolise and given long enough will die. Regeneration, the renewing of stock by growing out the existing seeds into seed bearing plants whose seeds are then returned to the bank, is thus a vital banking practice. Given the importance of the materials held at the seed store, it is usual to ensure that they are regenerated every few years or so to maintain stock viability. However, sometimes materials slip through the net. This is what has happened in this case, and the material Liz is handling is the original 1970s deposit.

The consequence of this failure to regenerate the materials is visible on the work bench. Amongst the envelopes, clean petri dishes, and seeds on the work bench, there are also numerous petri dishes whose contents suggests all has not gone well. These contain seeds which, after a week

or so spent in the warm conditions of the germination chamber have failed to germinate and have instead gone mouldy. Because of their age, viability levels are not good.

It is clear which seeds have successfully germinated. They have a small root, around 2cm long, and do not exhibit signs of decomposition. Sayers transfers these successes into small pots full of compost, presses them carefully down under the soil surface, and waters them. A label is written with the details from the petri dish lid and pushed into the edge of the pot. The regeneration of accessions is achieved simply by growing the seed into a plant, and collecting the seed from that plant. The practice is known as "growing out". To get a good number of seeds for the new sample, Sayers is hoping to grow six plants of each accession. However, because germination rates are so low for many of the existing samples, she will settle with whatever she can manage below this number. Even just one plant is likely to produce at least one ear of grain, or around ten to twenty seeds. Although this is inadequate for a complete sample, these seeds can themselves be regenerated the following year to produce a good number. For seeds resolutely failing to germinate, she uses some tricks to encourage them, such as putting them in a machine called a vernalisation chamber which simulates the cold conditions of winter which prompt growth in some varieties. However, from a couple of envelopes it is impossible to find seeds which germinate and as a consequence those accessions are lost from the collection. Over the following fortnight or so, Liz works to ensure that as many varieties as possible are germinated.

My next interaction with these accessions takes place in early June 2011.

They are now fully grown plants, each around 80cm high, and are growing in greenhouse space the seed store has had allocated to it for this purpose. Each plant has two or three ears growing on it, although at this stage the ears are quite immature. The air is thick with pollen although Sayers assures me that these grains are self-pollinating. Although some pollen is released into the air, the plants' physiological make up is such that the female part of the plant is adapted so that it is much more likely to take on its own pollen. As such, genetic mixing is unlikely occur. That said, because of the importance of maintaining each variety in a stable way, additional precautions are undertaken to be sure that there is no chance of cross breeding. Over each ear is put a small transparent plastic bag, one designed for exactly this purpose, which is folded at the lower end and stapled shut. This transparent bag is not completely air tight, as this would damage the maturing grains, but it does act as a pollen barrier making the possibility of pollen getting in or out so low as to be not worthy of consideration. Thus, as the grains mature it can be almost guaranteed that they are self pollinated. Consequently Sayers is certain that the seeds, which will be harvested later in the year, will be genetically identical to their parent generation. The result being that, when she returns these accessions to the seed store's freezer, each variety and the traits it carries will be the same as that which was originally deposited back in the 1970s.

(Assembled from Research Diary entries of 9 February 2011 and 7 June 2011)

What is demonstrated by this narrative is that this practice of growing out material, a practice so key to keeping plant genetic resources over the boundary point of being plant genetic resources, is a practice which mixes order

and disorder in relatively equal measure. The JIC, an organisation steeped in conventional scientific practice where research is undertaken at the forefront of knowledge on plant biology and plant breeding it may be, but it is still required to engage with the disordered materialities inherent to working with seeds. In this case those materialities began in the fact that, whether due to having been lost at the back of a shelf or their entry being missed on a spreadsheet, some plant genetic resources evaded enrolment in the usual maintenance regimes (in fact, that this occurred at one of the UK's best funded and most prestigious seed banks vindicates Fowler's comments on his fear of the "steady drip drip drip of extinction" which are cited in the section above). This matters, because seeds are not immortal. Without being regularly maintained, the seeds of an accession will cease to be viable. Regeneration is also a messy process because it involves plants husbandry, and plants do not always behave predictably. Trial and error with vernalisation was found to have as much of a role as rigorously repeated and established protocol.

However, one situation stands out in which disorder is not permitted, and that is represented by the bagging of the seed. Seed is bagged to ensure genetic integrity and continuity between one generation and the next. For under the JIC's regime, the genetic information represented by the sample in each accession must remain as constant as possible over generations of seed. Maintaining plant diversity, maintaining variety, is absolutely at the core of what the JIC does, yet because of the way the JIC makes use of the material in its collections, variation within an accession must be avoided. For varieties where it is possible, by which I mean varieties which either have a preference to self pollination or which will readily self pollinate without this adversely affecting the viability of the following generation, self pollination is the route to engendering

that genetic repetition over generations¹⁹.

I now turn to consider how the practice takes place at the HSL.

Stock regeneration at the HSL

At first glance, practices at the HSL appear to have a good deal in common with those of the JIC. The HSL stores a huge number of varieties which it too calls accessions, issues samples of them to its user groups, and when necessary replenishes their stock by growing plants out and harvesting their seeds.

Notionally, practices of plant husbandry, and indeed the messiness, of stock regeneration are very closely echoed. However, when under direct comparison, there are marked differences in the details of practices between the two organisations. Most obviously, at the HSL, not all regeneration occurs on site.

As well as regeneration undertaken on site by their own staff and off site by contractors, the HSL makes use of volunteer members called seed guardians (whose role is outlined below) who regenerate material in their gardens or allotments. HSL staff estimate a forty-sixty split between the staff and contractor method and the seed guardian method (Research Diary, 2 November 2010), with guardians undertaking the larger proportion of regeneration. The most visible outcome of this difference in practices between the HSL and JIC is

19 The JIC will grow out several thousand accessions each year, and not all can be grown out in this way. Of grains, most are grown in open conditions in one square metre field plots, and their genetic integrity is maintained simply because of these plants' preferences to self rather than cross pollinate. This seed in this example is bagged for several interrelated reasons. First, because it is high value material as there are so few seeds of the previous generation and, second, because it is being grown out in the greenhouse (which is too a function of the valuable nature of the material). Bagged seed is more routinely used in the regrowing of precise genetic stocks. Being grown out alongside this historic material was a selection of seeds from several hundred experimental lines created from the crossing of wheat varieties Avalon and Cadenza. Without the precise genetic make up being preserved over generations, future experimental work on these crosses would be rendered valueless.

one reflected materially in the way that variety and variation are produced in the plant genetic resources the organisation maintains. The JIC, as is observed above, seeks where possible genetic regularity from generation to generation. The HSL too seeks similar regularity, known by the organisation's practitioners as keeping a variety "pure". However, it also seeks both genetic diversity within varieties, itself an inevitability when dealing with the open pollinated varieties that make up the bulk of organisation's stock, and further seeks to maintain the presence of that diversity over generations – a practice which, as I shall go on to show, necessitates a careful balancing act between the moving of too little or too much variation between one generation and the next.

In this part of the chapter, I examine the work of regeneration on site and the work of seed guardians, beginning with and focussing on the latter. A seed guardian is an HSL member and volunteer who agrees to grow out a sample of seeds from a variety for which stocks are running low in order that they might bulk up the stocks. Usually, two or three guardians are sent samples of the same variety, both because it would be unreasonable to expect one grower to supply enough stocks for the whole library and because it provides some security should one grower be unsuccessful in regenerating the material. Illustrating my discussion with a mixture of interview material with seed guardians and field notes taken on site at the Library, I will outline these practices of seed guardianship. In this section I pay particular attention to the way that practices seek to manage genetic variation over generations. This influences seed guardian practice from the very start, as Dr. Debbie Brunton, discussing which varieties she decided to take on, explains:

I picked the things that were easy. Because some things you have to keep isolating and I- one of the problems of growing on an allotment is

that you're very exposed to everyone else's gardens. [In an effort to keep the varieties pure, DB then decided to carry out her seed guardian work in her garden at home. However this limited her options in other ways, as she will explain later in this extract.] But the problem is the HSL. They're very good. They send around a list at the end of the year saying 'we're looking for guardians for these things, would you?' and it's like- in the same way that I take in rescue cats, I find it quite hard to say no. It plays on my sympathy. [...] But I'm also beginning to run out of space. As you'll see the garden is very small, and I have to do things that don't naturally cross pollinate. So although I'm looking after a few things I'm quite limited in the kinds of things I do. I've occasionally thought about doing something like a squash or something, where you hand pollinate, but I had a go at it one year and it didn't work, so I never tried it again.

(Brunton, interview, 13 April 2011)

A similar sentiment is reflected in another seed guardian, James Dennis' experience:

OZ: Could you talk me through your seed guardianship. I guess you were sent an orphans list, tell me about that, and how you decided what you wanted to grow.

JD: Yes, they sent me through paperwork about which varieties were on offer on the orphans list and how to grow them as well. And I decided- because I'm not a very experienced gardener and I'm also quite busy in my life so I knew I wasn't going to be able to put that much time into it or have that much expertise to know how to grow these things. [...] So I wanted one variety of something that was simple and easy to grow, it

wasn't going to cross pollinate with the things around it, and it wasn't going to need and special tender loving care to grow, and would really just get on with it. So I could just prepare the ground properly and plant it, and let it get on with it. And I decided on a French bean.

(Dennis, interview, 5 April 2011)

Preserving varietal purity by preventing unwanted crossing between varieties is something which seed guardians tend to find difficult. As such, most guardian varieties are self pollinators. Varieties which must open pollinate, such as brassicas, tend to be regenerated in house, as they require slightly more technical knowhow and access to facilities most hobbyist gardeners do not have access to. During my field work visits to the HSL, I worked with volunteers and the organisation's horticulturalist, Clare Pritchard, assisting with the tidying of what had, earlier in the year, been a bed where brassicas were grown out. As we were digging the earth and removing dead plants, she explained the process to me. Below is her outline of the practice based on recollections written in my research diary, with an additional observation taken later from conversation with Cooke, recorded in my research diary in note form, included in square brackets.

Because the HSL seeks to maintain a degree of varietal purity from one generation to the next, open pollinated plants which are by definition quite hard to keep pure, are regenerated by the organisation in their grounds. [Before planting begins, a sample of seeds is obtained from the seed library's stocks. If several growers have grown this variety out in the past, or for another reason there are several reliable samples of the same variety in stock, staff will select seeds from each of the samples in an effort to ensure the following generation can most widely represent

the genetic variation of the previous generation.] The seeds are planted and the plants are grown up in an ordinary fashion. When transferred outside, they are planted in rows, over which mesh tunnels are installed. These mesh tunnels allow sunlight, rain, and fresh air to penetrate but prevent access by insect pollinators. At the appropriate time, a population of blow flies is introduced into the mesh tunnel. The blow flies provide the insect pollination necessary for the variety to produce seed successfully, but prevent any pollen from other varieties being incorporated into the variety and thus ensuring that varietal purity is retained for another generation.

(Research Diary, 20 October 2010)

While at the JIC, absolutely accurate replication of genetic material between generations is required where possible, at the HSL there is a different approach. Varietal purity is important, of course, for a variety must grow out in a way that is true to the expectations for that variety. However, the difference lies in the way that the JIC makes efforts to ensure purity that entails exact replication of individuals, while purity at the HSL is something born of maintaining continuity across a population. The practice of maintaining varieties at the HSL, ensuring the great diversity of heritage seed varieties continue to be in distribution, requires that the pre-existing diversity or genetic variation to be included within that variety. Put differently, where in many cases for the JIC genetic variation is to be avoided whenever possible, at the HSL genetic variation is tolerated and even encouraged within varieties so long as, and indeed in order that, the accession's population as a whole continues to be representative of all the genetic variation that the variety is known for. Indeed, it is for this reason that seed guardians tend to prefer not to work with readily open pollinated varieties, for they fear that their guardianship of that variety could introduce too much

variation, perhaps by the introduction of pollen from a neighbour's garden or allotment; but yet when populations are grown out on site, a mixture of seeds from different samples is selected to ensure all the available genetic variation is incorporated. In fact, at the HSL variation is more than tolerated, it is encouraged. For some members variation has an aesthetic appeal, they want to garden with plants which do not look identical in the way that those grown from commercially produced seeds tend to look. Further, the genetic diversity that comes of variation within a variety is thought to be beneficial to populations of plants, providing them with a richer genetic toolkit and thus making them better enabling them to adapt to the circumstances in which they are grown. As HSL members are encouraged to save seeds from one generation to the next, rather than returning to the seed catalogue for new seed each year, this broader genetic range is thought to be useful in enabling those plants to adapt to the various environments into which they might be introduced.

Coordination work in regeneration practice

In this section, I have demonstrated how the practice of regeneration acts as one which keeps seeds across that boundary point discussed above and in the realm of plant genetic resources. The practice of regenerating stock is a necessity to replace material which naturally degrades over time, as well as the replacement of material withdrawn for utilisation by seed bank user groups. However, the practice of regeneration also acts as a mode of coordinating between different versions of plant genetic resources. For while there are differences exhibited between the specificities of practice in each of the seed banking milieus, in a broader sense, the concerns each version of seed banking deals with, and the way they go about dealing with them, are very similar. Principally, each must ensure that their seed bank contains an adequately sized stock of viable materials which accurately reflect that which was initially

deposited. As such, the multiple strands of the plant genetic resources concept are shown to be held together through the coherences between the way it is practiced in its various settings. Next, I add further evidence to this argument by examining the way seed bank accessions are known about.

Informing stock

In this section, I will examine the ways by which the materials of seed banks become the materials of plant genetic resources through being affiliated with information, reflecting what Andrew Barry (2005) has termed the “invention of informed materials”. Information and seeds come together in a variety of ways. In general, information is necessary because, even to the trained eye, a seed reveals little beyond basic details such as species or perhaps in some case variety type, and because further investigation would usually result in the destruction of the seed either through its being manipulated in a lab or its being grown out into a plant. As such, the accrual of information directly associated with a particular accession is a vital component of that accession's seed becoming a plant genetic resource in all seed bank milieus. This is because, as a document from Biodiversity International advising on the accumulation and management of information about banked seeds, puts it, “people cannot use genetic resources that lack essential information” (2007, p. 1). In this section, I will examine how information practice plays out in different seed bank contexts. I will argue that, the practice of creating an informational landscape for seeds to inhabit is a central part of maintaining the status of those seeds as plant genetic resources as well as maintaining the coherency of the plant genetic resources concept more broadly. I shall also argue that the ways that information is created and the types of information prioritised themselves do work which contributes both to how seeds are made into plant genetic resources and how those plant genetic resources then go on to be utilised in

future.

As a rule, most seed banks follow a relatively regularised practice of recording basic information about their plant genetic resource material. Although there is no absolute standard, most basic data recording follows the protocol laid down by Biodiversity International's above mentioned handbook *Developing Crop Descriptor Lists* (2007). The document outlines in detail precise ways of recording phenotypic information about crops, by which I mean the physical characteristics expressed by the plants, often in standardised numerical or diagrammatic form. Although this kind of data is important, it is not the subject for analysis in this chapter. Although, particularly at more conventional seed banks like JIC or SSV, research participants reported in conversation the means by which such data serves a useful purpose, during my ethnographic work I did not witness this data being incorporated into practice in any noteworthy way. As such I shall direct my analysis at the kinds of data creation and manipulation practices which I did witness.

I shall begin by examining how, at the HSL, seeds are known by seed bank staff and users through the creation of variety files that feed, amongst other things, into the making of an annual seed catalogue sent to seed bank members. I shall then consider a second story, this time at JIC, in which the information seeds are couched in by the organisation's staff enables them to move beyond the seed bank. In each case I shall argue it to be this information which enables the seeds to maintain their status as plant genetic resources by in some way maintaining their utility or potential utility to groups external to the seed bank.

Pictured, is row of filing cabinets that sit adjacent to the entrance to the HSL's office (Appendix 3, Figure 3). Within these filing cabinets are the variety files, a series of cardboard wallets which contain almost everything the HSL knows about each of the approximately 800 varieties it holds in its library. But such filing cabinets are an unusual presence in the plant genetic resources milieu. Following the kinds of techniques promoted by Biodiversity International, as mentioned above, most seed banks would be able to store almost everything they know about the materials in their possession as numerical data on a spreadsheet, that data having been collected through the scoring of particular characteristics of an individual plant or a population of plants according to predefined quantitative scales. But the HSL is different. Although they do not avoid such quantitative data entirely, and it is accrued particularly for internal use, as HSL manager, Neil Munro, notes in interview (April 2010), theirs is an organisation that deals mainly in "stories". It is because of the nature of those stories, their origins and the format they are in, that such a vessel for knowing seed library material is necessary. In this section I will demonstrate the ways that knowledge about the seeds in the HSL's collections works in turning the library's seeds from being envelopes of generic materials into instead what are, for the specific requirements that this library's users have, a version of plant genetic resources. During my research period at the HSL I spent an afternoon examining the variety files. This extract from my research diary gives a flavour of the kind of material that a variety file might contain:

The variety files are contained in a set of large filing cabinets, ... and held in card folders stored in alphabetical order by vegetable type (e.g. carrot) and then by variety (e.g. Afghan Purple). I look through a particular variety file at length, in order to get a greater understanding of

the kind of information they contain. There are nearly four full filing cabinets of files, and I'm at a loss as to which files to look through. ... The examination of this one variety file, Crimson Flowered Broad Bean, was chosen simply because it seemed to be the fullest I could find [the file was about five centimetres thick].

The variety has a long history. It was first sent to the library with a letter dated 1 October 1978 by a Rhoda Cutbush, when Cutbush was aged 73. The original letter, short and in a neat fountain pen handwriting is included, as is a follow up letter, typed, from Laurence Hills [the HSL's founder] requesting some more seeds of this variety, which Cutbush duly returned later in November.

Other documents in the file include photocopies of mentions of this variety in a gardening book called the *Gardener's Calendar* which is dated 1809, as well as several other references from old gardening books. It is clear that this variety is of particular interest, and, upon mentioning that I am looking at this variety to Vicki who is in the seed sorting room with the volunteers, all seem aware of its existence and status as being of particular importance. It transpires that the colour of the flowers is notable (most bean flowers are white), and that its growing can be traced back in time for a significant period, as late as 1778 according to the HSL's website [consulted later] and for even longer periods according to Vicki. There is also a draft academic paper included from a Dr. Bond who has identified the allele responsible for the colouration and who later published his work.

The variety has become extremely popular, and was included in a TV

program made by a Japanese production company for Japanese television. Also included in the file are the exchanges between the HSL and a residential care home for the elderly in which Cutbush then lived. Plans for the TV program are outlined in the letters, which were to include a ceremonial handing back of a sample of seeds to Cutbush and a member of HSL staff talking about the variety.

In 1999, a letter was received from a member asking why there was such excitement about the variety amongst members. The letter's author suggests that the variety produces fewer pods and fewer seeds per pod than many other varieties, and that the attractive colour of its flowers do not make up for this. The letter is evidently regarded as unusual by the recipient at HSL for it has a yellow post it note label attached to it which reads "'Anti' Crimson-Flowered Broad Bean!".

The bulk of the file is made up of return forms from guardians. The return form outlines the experiences of each seed guardian who grew the variety out – from growing tips to bean taste.

(Research Diary, 2 November 2010)

That libraries of heritage or heirloom seed varieties work to engender narrative stories about their seeds in comparison to the more technical knowledge that tends to be created at mainstream seed banks has, as is discussed in Chapter 2, already been observed by scholars (van Dooren, 2009). Consequently, it suffices to note that a similar practice happens at the HSL. Indeed, the "tale of two seed banks" which van Dooren tells, in which he compares the government run Australian Winter Cereals Collection and an NGO called The Seed Savers' Network, echoes strongly the two ethnographic case examples upon which this

thesis is based. However, van Dooren uses this article to put forward a critique of the way seeds are turned into genetic "resources" with "value" by mainstream seed banks epitomised in his text by the JIC-like Australian Winter Cereals Collection. Van Dooren's concern is twofold. First, that mainstream seed banks do not make seeds available to the public at large in the way seed saving and exchanging organisations do; and, as a related second, that they instead transform seeds into resources with value that is measured largely economically. What I shall offer here is a different take on that argument. Like van Dooren, I too am interested in the ways that seeds become genetic resources of value to their users. However, rather than proposing one version to be preferable to another, I want simply to examine in closer detail the ways that using the information held on the accessions of a seed bank makes that material into a resource that is suitable for the milieu in which that seed bank operates.

At the HSL, the information held in the variety files is used as the base point from which to compose the the seed catalogue. The catalogue is an A5 document of around thirty colour pages sent to members early in the year. Based on a combination of stock availability, stock popularity, and a desire to rotate catalogue contents so that all the varieties in the HSL's collections are made available to the public at least once every few years, around two hundred varieties are selected for inclusion in the catalogue. It is from the catalogue, which contains a short descriptive paragraph about each variety and in some cases a photograph, which HSL members select the varieties they wish to order from the organisation that year. Each paragraph offers, in a very brief way, a summary of the knowledge held in the associated variety's files. It contains snippets of cultural backstory, perhaps naming the donor who brought the variety to the library, or mentioning how or where the variety was typically

grown by gardeners of the past: Rhoda Cutbush's name, or the reference to the Crimson Flowered Broad Bean in the *Gardener's Calendar* of 1809; such details are the mainstay of varietal information in the catalogue. Generally, the paragraph will also contain physiological information, such as plant height or vigorousness of growth, particularly if it is out of the ordinary, such that gardeners are able to select varieties suited to the growing environment available. Finally, it will almost always mention what for most growers is essential, a description of the vegetable's taste. The role of the catalogue cannot be underplayed. Inclusion of a photograph routinely results in an increase in orders by a significant percentage, a fact taken into account when seed stocks are calculated and the catalogue is in its planning stage. Conversely, when, in 2010, a Yugoslavian tomato variety called Yugo was included in the catalogue, it was ordered by only six members. Most, Cooke postulated, were dissuaded by the variety's foreign origins (Research Diary, 20 October 2010).

My central assertion in this section is that, without information, irrespective of, say, the meticulousness and accuracy of the regeneration regime by which stock is maintained, it would not be possible to seeds banked at the HSL plant genetic resources. Without this information the seeds would simply be a bundle of materials, unusable by the gardening public at large for whom those materials have been assembled. The information available might not be comprehensive, may not answer each gardener's every question, indeed, the information might not even be wholly accurate, but it offers a starting point, a way by which to narrow one's search. HSL members are encouraged to save their own seeds year on year, rather than rely solely on the seeds ordered from the HSL for that year's growing. Thus, users make their selection based on their experience, what has grown well in the past and what they like; or, they seek

something completely different, a variety quite unlike what they would usually grow. Without this information, such decisions cannot be made. The seeds would no longer be a resource, they would be just an bundle of objects. While at other seed banks the information stored is different, as too might be the seeds and the user groups served, the assertion still applies. Seeds are only of use when there also exists a method by which they can be known. Without being known, I argue, they cannot accurately be conceptualised as plant genetic resources as knowledge is a critical route for users to access those seeds and thus allow resource status to be conferred upon them.

Material transfers from JIC

In this part of my analysis, I consider another way by which information is a vital component of the making of plant genetic resources. As I noted above, seeds need to be known in order to be plant genetic resources. However, as I shall argue in this section, it is also only possible for them to be plant genetic resources if they can be made physically available to user groups. In most situations, this is uncomplicated. The HSL moves all its seeds from place to place in padded envelopes sent through the postal service. The SSV is little different, transferring material via international courier services in packages specially designed for the conditions of the seed vault. Information is vital in both these cases. At its most rudimentary level, incorrectly addressed HSL material or deposits made at the SSV without correct labelling showing ownership and box contents considerably reduce the seeds usefulness.

However, it is to the JIC that I will turn my attention in this section. For as a research focussed seed bank that operates in the more conventional plant genetic resources sphere, it has strong ties with other similar facilities the world over. As such, staff are regularly required to send material to other

organisations, some of which may be overseas. Thus, it is not merely the practicalities of transporting the materials with which the JIC must concern itself, or the correct addressing of the envelope, there are two further informational practices essential to making this possible. The first, common to almost every seed transfer in the current era irrespective of the crossing of a national border, is that of the inclusion of a Material Transfer Agreement (hereafter known as an MTA). The MTA is a legal document which outlines the rights the recipient has on the seeds they have received and the obligations they have toward the organisation from whom they received the seeds. The second is a document evidencing that the seed has met the biosecurity requirements for overseas transfer beyond the EU, known as a phytosanitary certificate. Both sets of documentation play a critical role in the making of seeds into plant genetic resources. I begin by examining the MTA.

The MTA lays out the rights and responsibilities both parties have toward the genetic material being distributed. For an organisation like the JIC it offers assurance that material will be utilised according to commonly agreed international principles. Without an MTA the organisation would certainly be less inclined to distribute their material so freely, as they would be less able to ensure their preferences were upheld. Without the second, the biosecurity regimes set out to prevent the unwanted transfer of plant pathogens would be put in jeopardy, and recipient organisations would either be less willing or legally prohibited from accepting JIC material. For the JIC, a key plank of their seeds being plant genetic resources is related to the possibility of their material being freely available for distribution.

There are many possible ways an MTA might be worded, reflecting the many possible sets of requirements a material owner might wish to impose on future

users of their material. The MTA used by many organisations, the JIC included, is one based on that developed as part of the International Treaty on Plant Genetic Resources for Food and Agriculture. Having been ratified by the UN Food and Agriculture Organisation, this MTA (UN FAO, undated) entered into force on 29 June 2004 (although MTAs have been in use since before this time). Much has been written about the impact MTAs have had on the research environment (see, for example, Rodriguez, Janssens, Debackere, & Moor, 2007; Rodriguez, 2008). My aim here is not to contribute to these conversations directly, but to consider the role this particular MTA plays in the making of the seeds in the JIC's seed bank into plant genetic resources. I do this by thinking through key parts of the MTA itself.

As outlined in the MTA, it is usual practice that material which leaves the JIC may only do so on the grounds that it is to be used for food and agriculture related purposes only. This does not mean that all JIC material is prohibited from being used in any other context, but rather demonstrates the expectation that material which is released in standard circumstances does so to be used for such purposes. The JIC is, after all, a seed bank and research station interested solely in issues around food and agriculture. More significantly, the MTA has clauses which enforce openness. The UK plant genetic resources milieu is a small one and, as I found during my ethnographic work and in interviews, the commitment to openness and an ethic of sharing is widespread and strongly held. Comments by staff at the JIC revealed this institution was no exception, for them plant genetic resources are materials that are to be freely available.

The MTA prohibits recipients from claiming intellectual property rights on anything they produce using that material which might inhibit its the of either

that material in its original form, or biological derivatives from that original material when sourced from the new product. Put simply, any intellectual property rights that a material recipient might put in place must not prevent others from working with the original material; neither can it prevent others from working with genetic material first derived from the original material but then sourced from the new material (unless that original genetic material has been altered or otherwise manipulated in the creation of that new material). That openness must be ongoing. Recipients are not only obliged to act according to the rules of the MTA, if they themselves pass the material on they must do so ensuring those same obligations are followed by the subsequent recipient. Recipients are also obliged to share any information they garner through research and development work, and are also requested to share freely any broader "non-monetary" benefits they may attain from working with the material. Although commercial activity which does restrict access to the product created from the seed bank material is permitted, the owner of the product created or any subsequent purchaser is required to pay percentage of sales revenues to the governing body of the International Treaty.

Just as the aims of the MTA are to facilitate openness and material transfer, ensuring material's phytosanitary certification serves a similar purpose. Seeds which pose biosecurity risks to recipients will inevitably be less likely to be widely distributed, either because recipients will be wary of accepting risky material or because legal edicts will prohibit them from doing so. The tests required for phytosanitary certification of JIC material do not take place on site. Instead a sample of seeds is sent to the Food and Environment Research Agency's offices near York for testing. The work undertaken on site is merely administrative, as I saw when a request for material to be sent beyond the EU was made. In this case, cited from my research diary, a selection of seeds has

been passed to Sayers by a colleague at the JIC and she is arranging their dispatch to China:

Phytosanitary certification is important because there is a risk of inadvertently introducing pathogens into other countries. Countries have different requirements, although clean seed – seed free of other plant debris – is the minimum. Arranging phytosanitary certification begins by entering data online. Fera's [the Food and Environment Research Agency] website asks a number of basic details about the seeds to be dispatched, details which focus on the seeds themselves. Sayers must enter details about the seeds, their genus, species, common name, and variety; the quantity (as a figure) and unit (selected from drop-down menu); a description of the material; and the location in which it was grown.

The tests, Sayers tells me, are not undertaken on every seed, rather phytosanitary certification is awarded based only on a sample of seeds. In addition, that sample is sent by the seed bank to the Fera offices with the main body of that selection remaining at the JIC offices. This is demonstrative of the trust that exists within the plant science community, given the ease with which non-tested varieties could be dispatched within or instead of the selection. It is demonstrative too of the practicalities of running a large scale seed testing organisation. With her sample ready to go Sayers must also then decide whether to select a destructive test, a version of testing which the material which will lead to the destruction of the material, or a non-destructive test. The decision to choose one over the other tends to be related to the practicality of how many varieties are being sent at one time. If there are a large number of

varieties to be sent and seed is readily available, a destructive test is preferable because this removes the inconvenience of several small samples being returned from Fera, which must then be reunited with the correct main body of seeds.

Assuming phytosanitary certification is approved, the selection will be dispatched via a courier company, with this phytosanitary certificate included, to the requesting institution.

(Research Diary, 10 February 2011)

Coordination work in informational practice

Like the MTA, phytosanitary certification makes it possible for seeds to be practiced as plant genetic resources by embedding them within an informational landscape which enables them to be moved from one place to another. Furthermore, information is assembled on accessions which enables both senders and recipients to know about the materials being distributed, knowledge which is essential in these seeds being useful as the materials of a plant genetic resources milieu. As in the analysis of the previous two sections, although the practices underway at each site are not identical, the very fact of their being similarities in practice acts as a way of holding the concept of plant genetic resources together as one which is multiple rather than plural. What is more, the practice of informing stock itself does coordination work. By embedding material in an informational landscape that may be universally comprehended, and by making it more possible for material to be moved between one site and another, connections, or at least the possibility of connectedness, is built between plant genetic resources of one site and those of another. In other words, it becomes hypothetically more possible for one seed bank organisation to take on the materials of another, and in so doing practice

them into plant genetic resources in their own way. Indeed, this is what occurs when material is deposited in the SSV.

Conclusion

In this chapter I have made two key claims, which I have illustrated with empirical material. The first claim is that plant genetic resource status is not inherent or automatic, rather it is something which comes about due to seed practice. The second claim is that plant genetic resource status is multiple, so although it is practiced differently at different sites, there is enough coordination work underway between the outcomes of those practices that the plant genetic resources concept may be regarded as "more than one – but less than many" (Mol, 2002, p. 55).

In making those claims, I examined three key practices which go into making seeds into plant genetic resources. I began by suggesting that the entry of seeds into a seed banking regime was the first step in their becoming plant genetic resources. What became clear, however, was that simply entering seed into a seed bank's cold store was not the end of this process. Ongoing work was found to be required. Because seeds are not immutable and because, as seed bank stock, they are made use of by their organisation's audience, seeds require ongoing replacement or replenishment. Thus, growing seeds out into plants from which new seeds could be harvested was shown to be an essential part of plant genetic resources practice. Further, in order for seeds to retain their plant genetic resource status, additional work was shown to be necessary. To make seeds useful to resource users they need to be couched in a layer of information. This may be, as I showed in my first example, information enabling users to make decisions about which seeds they need and how they might wish to use them. In other cases, as I went on to discuss, that

information might be to facilitate their distribution by setting the political parameters for plant genetic resource use, or giving the materials the right to travel across international borders. My assumptions early on in the research process, that plant genetic resources status was both easily attained and stable, were shown to be incorrect. In short, I found there to be no simple, immediate, or permanent route to plant genetic resource status. Rather, it is something which takes work to engender and which requires ongoing practice to maintain.

Plant genetic resources status is also something multiple. As was demonstrated by my analysis of each of the outcomes, there is no certain or definitive series of practices which must be followed that drives seeds to attain plant genetic resource status. However, there is a general coherence in the type of outcomes which must be achieved. A seed cannot be regarded as part of a plant genetic resources framework if it is not in a seed bank, if there is no capacity for its regeneration when necessary, and if it is not couched in an informational framework.

The ideas of this chapter underpin, and are built upon in, the rest of the thesis. In the following chapters I continue to investigate the term, practices and materials of plant genetic resources. However, I switch my attention from the work undertaken to bring them into being to look instead at the work those plant genetic resources themselves do in the world. In the following chapter, I argue that the practice of banking plant genetic resources is itself a practice of having, and responding to, concerns about future food security. In various ways, I investigate temporalities engendered by the materials introduced in these chapters.

Chapter 6: Seeds and the future

Introduction

In this chapter, I consider the way food security is brought about in practice in the plant genetic resources milieu. Building upon the arguments of the previous chapter, in which I demonstrated the way seed banking practice works to incorporate seeds into the framework of plant genetic resources, this chapter investigates how both seed banking practice and plant genetic resource materials operate as key pillars in the bringing about of food security. The contention to be developed will be one centred on the concept of temporality, arguing that the food security work of plant genetic resource preservation comes about as a consequence of the folding together of pasts, presents and futures in the practices and materials of seed banking

This chapter advances the notion of food security as a process which was introduced in Chapter 2. In that discussion, I referenced recent publications from the UK science and policy literature (Government Office for Science, 2011a, 2011b; Royal Society, 2009) to argue that in contemporary utilisation of the terminology food security had ceased to be regarded as a state which could be achieved; instead food security had come to be framed as a process, centred around ideas such as resilience, insurance and preparedness in relation to uncertain and ever changing futures, and, as such, was something always on the way to becoming. In the light of such a framework, the investigation of food security becomes an investigation of the work which goes into bring food security into being, or, in other words, food security practice.

Ideas of temporality are employed in the development of these arguments about food security. I draw, in particular, upon understandings of anticipatory action and the notion of “preparedness” as they have been conceptualised by Anderson (2010). In short, Anderson’s argument is that the unknown and unknowable nature of the future causes concern in the present, prompting actions which aim to assuage that concern. It is that, as I shall argue, which underpins the role seed banking plays in efforts to bring about food security. Although, by its very nature, the precise form the future will take is unknowable, it is possible to make predictions based on knowledge of the past and present. Preparatory action in the present is founded upon such predictions. The chance of what is feared in the future, or what Anderson terms the future’s “bad surprises”, coming about, may be reduced by preparations made in the present. In other words, rather than regarding past, present and future as detached from one another, they should be understood as being intimately related; following Adam and Groves’ assertions, the future is always “*living within the present*” (Adam & Groves, 2007, p. 121 emphasis in original).

Food security and temporality interface in this chapter in the following ways. In the first section, I examine the conceptual framework behind the way seed banking functions as a preparatory practice. Basing the section on an interview undertaken with Fowler of the SSV, I make a case for plant genetic resource preservation through seed banking to be comprehended through the lens of preparedness. This is done by considering how being without sufficient plant genetic resources would be regarded as having failed to prepare, looking at what seed banking is thought likely to make possible, and reflecting on what the future might be like if seed banking were sidelined in favour of technically derived sources of plant genetic diversity. In the second section, the preparedness concept is examined in practice. The way the act of regeneration,

the generation of new seed bank stocks through the growing out of old ones, works to bring about preparedness is thought through. The third section draws together the analysis undertaken in the two preceding it by examining two examples of the utilisation of banked seed materials, research projects at the JIC and the Organic Research Centre. By framing these examples as future scenarios, a framing justified by the relatively long period in which seed banking has already been underway, the section considers how current preparatory practice makes a diversity of futures possible.

Seed banking as a preparatory practice

In this section, I explore the conceptual framework underpinning the way temporality will later be shown to function in the work of making improved future food security scenarios more likely through the practice of seed banking. In particular, I argue that the model of temporality at play in practices of conserving plant genetic resources should be understood as one of preparedness (see Anderson, 2010). This is because, as will be demonstrated over the course of this section, it is currently considered highly probable that such collections of plant genetic resource material will be of utility in future plant research and variety breeding activities, and that will be undertaken with the intention of improving food security outcomes.

Three points are examined in the development of the preparatory thesis. I begin by developing the case for preparation by examining the predicted effect on future food security scenarios that could come about were there to be an insufficient reservoir of plant genetic resources available. Second, the opposite scenario is considered, and I look at the act of preparation in the framework of what plant genetic resource preservation makes possible. Finally, I support this argument by inspecting the risks of failing to make such preparation and

instead relying solely upon alternative sources of plant genetic diversity, specifically, sourced through a practice termed mutagenesis. The argument is developed through analysis of key sections of an interview with Fowler. As one of the key proponents of the SSV, highly influential in both its establishment and its ongoing work, Fowler's practical and intellectual expertise is in the field of the long term impacts plant genetic resource preservation. As such, his contribution makes particularly compelling evidence for this argument.

An insufficient reservoir of plant genetic resources

I begin the making of the conceptual case for plant genetic resource preservation to be understood an act of preparedness by highlighting how a failure to do so should be regarded as a failure of having appropriately prepared for the future. This argument builds directly on the work of the previous chapter, where it was shown that seeds become plant genetic resources as a result of seed banking practice. For what these excerpts illustrate, is that it is only by becoming a plant genetic resource that a food plant may be involved in the preparedness that comes of folding together past and future. Should such plants cease to be part of that plant genetic resources framework, their ability to play a role in those foldings is halted, irrespective of whether or not they become functionally extinct:

I remember years ago too, sort of discovering, if you will, the last three trees in a very well documented [formerly] commercial orchard in the mountains of Virginia in the Unites States. [They were] the last three trees of a particular apple variety that was not- that was very well documented as having existed in the 1800s but not documented as being held in any ex situ collection in the world. And here are these three trees. And, equally, such a tree could have been in your backyard, in

your garden, without you knowing what the variety name was, and without you knowing any of the characteristics of it *et cetera et cetera*. Now literally the tree- that variety- wouldn't be extinct, but in what way would the unique characteristics of that variety be available to another gardner, a farmer, an apple breeder? It wouldn't be.

(Fowler, interview, 8 November 2011)

Hence, while the loss of material from a seed bank should not necessarily be equated with extinction (although, in the case of many older varieties, this is quite a plausible outcome), it is the loss of material from the plant genetic resources milieu rather than extinction itself which is most significant from a food security perspective. It is this reduction in the sum of materials that are available to be folded into the future which concerns Fowler:

It reduces our options. If we had a complete inventory of all the diversity that's out there, I could really speak specifically about what's lost. But usually, when we lose diversity in a gene bank, it's in a gene bank that's sub-standard, frankly, which means that the documentation system's not very good, and they haven't had the funding to screen their collections and find out what they really have. If they had that kind of funding, they'd probably have the kind of funding to do a better job of the conservation. So very often we- it's a situation of akin to burning books that we haven't read yet. And, many of these varieties in these gene banks- they're in gene banks in the centres of origin of that particular crop. These are varieties that trace their history back to the neolithic, they have I think remarkable, potentially remarkable, characteristics. And yet we'll never really know what we've lost. What do we know about

Shakespeare's poetry and plays that didn't survive along the way?

(Fowler, interview, 8 November 2011)

In preparing for the future, the nature of banked seed as, what I termed earlier, a reservoir of material is shown to be of particular importance. For what the quotations demonstrate is that an argument in support of the preservation of plant genetic resources is, necessarily, an argument in support of the preservation of the many thousands of individual samples which make up that reservoir. However, making an argument for the importance of having access to a mass of plant genetic resource materials is, in fact, making an argument for the preservation of a vast number of individuals for which there is no guarantee of their utility. This is because, although seed banking is an act of preparation for the future, the future is always unknowable and indeterminate. As such, while it may be said with some certainty that plant genetic resources will be of use, knowing which samples will be of use, or, moreover, knowing how they will be of use, is impossible.

And yet, a future of insufficient plant genetic resource availability is one which, while unlikely, Dr. Fowler does regard as a real possibility. Of plant genetic resources, he believes, "there's some loss every day" (Fowler, interview, 8 November 2011). He distinguishes between two causes of material loss. The first are the major losses which occur due to significant environmental or social events, citing as examples flooding in Thailand around the time of my interview in 2011 and the risk of gene bank losses in Greece due to the financial crisis. These kind of losses are newsworthy, large events, ones in which "CNN functions as an early warning system so to speak". The second type are the minor losses, or what he terms "the steady drip drip drip of extinction in the normal gene banks", where the occasional sample is lost due to and

administrative error or fails to regenerate due to seed degradation (as with the wheat samples discussed Chapter 5). Thus, the undertaking of plant genetic resource preservation through seed banking without "reduc[ing] our options" (Fowler, interview, 8 November 2011), entails a commitment to the preservation of every individual sample.

What seed banking makes possible

Fowler describes seed banking, and the plant genetic resource materials it holds, in the following terms:

It's the biological foundation of agriculture. It's, in some ways, the subject matter of the first chapter of Darwin's *Origin of Species*. It's what makes evolution and change possible in our agricultural crops.

(Fowler, interview, 8 November 2011)

It is this statement which underpins the centrality of preparedness in seed banking regimes. In short, Fowler asserts the necessity of a comprehensive reservoir of plant genetic resources in making preparations for the future because, without them, the materials required for future plant breeding for food and agriculture will not be available. Seed banking is an act of preparation which ensures the retention of the material which makes "evolution and change possible" (Fowler, interview, 8 November 2011). In so doing, it is a tool which enables the folding of materials of the past, preserved in the form of the seeds of old varieties, into those of the future, those of new varieties. Fowler's assertion is that unless those materials of the past are preserved, the range of possibilities for further development of crop plants will be substantially reduced. Especially given banked seed enables future access to high levels of genetic complexity:

[M]any of the varieties that we're conserving in the gene banks have linked traits. One trait it linked to and dependent on another trait in that variety. And those relationships are incredibly complex. And historically, by definition many of them have been quite successful. So, as much as I talk to you about the gene bank collections being a repository or a collection of traits, they're actually much more than that. It's a repository of traits and relationships and combinations. There's a real richness there that will take us an incredibly long time [and] deep scientific work, to ever begin to understand. And there it is, just sitting right there.

(Fowler, interview, 8 November 2011)

This is of particular significance, for that "evolution and change" (Fowler, interview, 8 November 2011) has been central to improvements made in crop plants from the first settled agriculture to the present day, and, because of predicted environmental change, is likely to become even more pressing in future:

I think one of the things that drives us [to bank seeds] now would be the role that, the increasingly important role that, crop diversity is going to play in dealing with climate change adaptation. It will be essential to human beings adapting to climate change because our agricultural system is going to have to adapt, and that means that crops are going to have to adapt. And that means that they're going to have to have traits that will allow them to prosper and be productive in a dramatically new climate. And agriculture, frankly, is not prepared for that right now, we're really not ready. The varieties that are in the field, and in specific fields,

around the world, are not themselves adapted to the environments that are going to surround those fields, the climates that are going to surround those fields, in the near future. So I think that these ex-situ gene bank collections are going to become more and more important because of the storehouse of traits that they contain for climate change adaptation. And that, of course, is a component of trying to achieve some kind of food security in the world.

(Fowler, interview, 8 November 2011)

This notion that agriculture is “not ready” has a double meaning. First, the plant varieties presently in use are unsuitable for the future climates in the places they are currently grown; but, second, the infrastructure which is to be relied upon to develop the new varieties needed is itself presently unprepared. This is reflected in his comments on the opinions held by some in the private plant breeding industry on the importance of seed banking:

I talk with a lot of private sector people [in agricultural plant breeding], and I have over the years, and very often their attitude is 'well, you know, the gene banks are nice and that's okay and we certainly support you doing that. But it's not too important to us.' And I say, 'well why's that?'. And they say, 'well we have everything we need on the shelf right now for our breeding programmes.' So I said, 'what's the time frame of your breeding programmes?'. And they say, 'oh ten years.' So I say, 'well great, but what happens after that, do you have everything on the shelf that you need for year 11, 20, 50 or 100?'. Well, they don't think that far down the road. So, sooner or later, they will come back to the gene banks.

(Fowler, interview, 8 November 2011)

Fowler's assertion is that the temporal purview of the necessity of plant genetic resources in private sector plant breeding extends to commercial time scales, not those of food security. As such, they regard the materials they have stored internally as being adequate for their breeding needs, without having attended to the fact that, by its nature, preparing for food security does not have such convenient end points, rather it inevitably extends from the present into perpetuity. Seed banking thus takes on a role of infrastructural development, such as doing the groundwork for a network of cooperation, some of which is inevitably international, which will be necessary for future plant breeders to access the materials they are likely to need (although Fowler implies at various points elsewhere in the interview that he is critical of the extent to which seed bank curators have chosen to engage in this network):

[W]e can't have a successful sustainable system for conserving genetic resources if every country is trying to do it by themselves without cooperating with others. Because nobody has a complete set of the diversity. Every country is just totally dependent on other countries for their genetic resources. So it means that there has to be cooperation. ... [This is because] the breeding materials that country A is going to need in the future are going to be less and less sourced from the gene bank in country A, because the gene bank in country A has materials that are derived from the historic climate of country A, not the future climate. And the future climate is going to need different traits that almost by definition are going to be sourced outside of that country.

(Fowler, interview, 8 November 2011)

It sum, I argue that, preparedness is enacted by seed banking in two

interrelated ways. First, seed banking is undertaken because some of the individual varieties within the reservoir of materials of the past that the practice conserves are thought likely to be necessary for the bringing about of future food security by plant breeding. In other words, seed banking is an act of preparation which allows the repetition and development of a food security practice, plant breeding, which is already undertaken in the present. It draws on knowledge of the present, in which plant breeding is routinely undertaken, to prepare for a future in which plant breeding is foreseen to continue.

Second, however, seed banking is an act of preparation for situations aligned with but beyond plant breeding; by which I mean, seed banking is shown to be a practice by which preparations are made for changes in the world at large. In Fowler's example, seed banking acts as a way by which preparations are made for a future food system disrupted by an altered climate. However, climate change scenarios are not the only "bad surprises" (Anderson, 2010, p. 780) for which seed banking makes preparations. As such I argue that, seed banking is an act of preparation for change itself, whether it be a consequence of a changing climate or something else with the potential to destabilise the food system. Likewise, seed banking is an act of preparation for improvements to technical practice. Fowler talks of seed banks as "repositor[ies] of traits and relationships and combinations" as yet too complex to either identify or make use of. However, seed banking makes preparations for a future in which working with this complexity will be possible. In the undertaking of these practices of preparation, the materials of the past, the seeds of old varieties of which some will confer traits useful to new plant varieties, are incorporated, or rolled, into, the future.

Alternative sources of plant genetic diversity

The role of plant genetic resource preservation as a practice of preparedness for the future rests upon the expectation of its utility in the future. In other words, if the work that seed banking does is superseded by an alternative technology which is less expensive or more effective at bringing about the necessary "evolution and change possible in our agricultural crops" (Fowler, interview, 8 November 2011), then seed banking would cease to be a useful preparatory act. Alternative, technically derived, sources of plant genetic diversity do exist, in particular those generated by the intentional creation of mutations through biochemical means; a practice termed mutagenesis (Ahloowalia, Maluszynski, & Nichterlein, 2004; Ahloowalia & Maluszynski, 2001; Pathirana, 2012; Xu et al., 2012). However, as Fowler contends, it would be unwise to prepare for the future by relying solely on such developments:

[L]et's talk for a moment about the landraces, the farmer varieties, [...] and the crop wild relatives are the backbone of- that's the gene pool really of our major crops. And the farmer varieties are the result of farmer's selection over hundreds of human generations. We can't recreate that. We can't recreate the climates that they experienced, we can't recreate the many many different versions of pests and diseases that they experienced. And for which there may be resistance embodied in that old variety that we can't actually even test for because that variant of the disease or pest is not around any more. Not to say that it's not lurking out there somewhere, but we don't have it [at present], so we can't test for it. ... I don't think we're going to be able to recreate this [genetic diversity we have currently in seed banks] and, moreover, why would we want to recreate something that's so easy and cheap to save in the first place? I mean, I sometimes have scientists say to me, 'well

Cary, in the future, we'll be able to just recreate all this stuff and design plants and genes to order.' And my reaction to that is, 'well great, congratulations, I'm glad to hear it.' But I don't- [first,] I don't plan my life and my work with the assumption that a miracle is going to take place, even if you tell me it is; and second, if you're able to recreate this particular variety, sample A, in this gene bank in the future, tell me how much it's going to cost, because I can tell you very clearly how much it will cost to conserve variety A that we already have in the gene bank for the next fifty years. And it will be I think next to nothing compared to what it will cost you to recreate it. And that's if you'll be able to do it. So it seems to me that it just behoves us to conserve what we have now. (Fowler, interview, 8 November 2011)

As Fowler states, in spite of the possibilities that a technoscientific future might offer in theory, it would be imprudent to centre them in the preparations made for the future. This is particularly so given the value of the material saved in seed banks as they currently stand, a value that comes in large part as a consequence of the "experience" (Fowler, interview, 8 November 2011) plants have in their history and which is recorded in their genome. In spite of assertions to the contrary from some practitioners in the field who argue that the future necessity of seed banking may be reduced as a consequence of technical advances, continued seed banking remains central to preparatory practice which, while it recognises the possibility of future technical development, also recognises the necessity of retaining access to known technologies and resources of the present.

Having a conceptual case for the understanding of plant genetic resource preservation to be regarded as an act of preparedness, in the following section

I examine how that preparedness is brought into being in practice.

Preparedness in practice

The argument to be presented in this section is centred upon the assertion that what is to happen in the future is always “incubating in the present” (Anderson, 2010, p. 780). Building on the conceptual justifications for seed banking as an act of preparedness outlined in the previous section, here, I shall investigate how current seed banking practice works to bring that preparedness into being. In so doing, I shall focus on the work of seed regeneration (also discussed in Chapter 5), arguing it to be the principle route through which work on the future is undertaken materially at each seed banking milieu

I shall make two key points in this section. First, as will be demonstrated, this futuring work hinges on the notion of perpetuity. Because events of the future cannot be known, the endpoint of the necessity of preparedness work cannot be known either. For example, there may be a point at which mutagenesis becomes a more effective and reliable way of sourcing the genetic diversity needed to improve food security. However, as it is impossible to know if or when that point might arrive, effective preparedness is centred on its never arriving. As such, acts of making preparations for the future are ones which necessarily, in practice, make preparations the outcomes of which are intended to last indefinitely. Second, I will argue that the practice of preparation in the plant genetic resource milieu is one which must engage with two versions of the future simultaneously. For while seed banking must act to prepare for a future which extends into perpetuity, few seed banks – the SSV being the key exception – have the privilege of this being the only future they must engage with. For most mainstream seed banks, engaging with the future entails preparing for perpetuity whilst also responding to the needs of their user

groups in the nearer future. As such, I argue that preparations for perpetuity come to be articulated in a stepwise fashion from one point in the near future to the next.

The routes to perpetuity

The act of banking seed is, by implication, an act which seeks preservation for perpetuity. I use the verb imply deliberately because, although all seed banks are in the business of saving seeds for the future in order to engender preparedness, in fact, of the three, only the SSV has an avowed agenda which states that the seeds it stores are intended to remain available in the very long term. At the other two sites, the JIC and the HSL, perpetuity exists only as an implication drawn from the fact that neither has an explicit or implicit end point for their activities. At no site is there an indication that their material is predicted to become obsolete or unnecessary either by a particular date or in a certain era; nor is obsolescence expected as a consequence of a technical, cultural or other milestone being crossed. As such, although it may not be explicitly stated within the discourse of seed banking, embedded within practices at all my research sites is a reflection of that notion of retaining materials in perpetuity.

The importance of this emerges in the practice of, what I term, the route to perpetuity. While the vocabulary of perpetuity implies a continual or ongoing flow, its bringing into being, which, as I shall demonstrate, takes the form of repeated, punctuating steps, belies this implication. Perpetuity is, in significant part, brought into being by the practice of the regeneration regimes first examined in Chapter 5. Thus, it is in the doing of those regeneration regimes where, as I shall go on demonstrate, the temporality of preparedness is negotiated. This is because it is at these points where, materially, past, present

and future come into contact with one another. In other words, while conceptually seed banking might be about maintaining banked materials forever, something which implies continual flow, it is at these points of regeneration, these punctuating steps, where this perpetuity is brought into being. It is at these times where the materials of the past, the materials produced through plants having been grown out at an earlier time, become, by their being grown out, the materials of the present. This is something which is done with a view to creating materials which, as a consequence of their being banked, become the materials of the future.

Regeneration is a core practice at every seed bank. This is because seeds are not immutable, they degrade over time. However, as was indicated in Chapter 5, the practice of regenerating stock is, in most circumstances, a practice driven by causes other than stock degradation; most commonly, by stock depletion as a result of samples being issued to user groups. What is more, each seed banking milieu undertakes its regeneration regimes in different ways and each does so at different intervals. In other words, although following the same general principles, the steps towards perpetuity are undertaken differently by different seed banks. At the HSL, stock regeneration, a task often done by informal volunteers called seed guardians, routinely occurs at the minimum of once or twice per decade and, for some varieties, every year is not uncommon. By contrast, the materials deposited at the SSV are regenerated by depositor organisations according to recognised protocol (such as that outlined by Engels & Visser, 2003), a practice predicted to be necessary perhaps as infrequently as once per century for most varieties. At the JIC, regeneration techniques are similarly formal and materials are stored in conditions which make viability similar to the SSV hypothetically possible, although in reality most samples are regenerated at intervals of between once every decade or

two, to, for those samples in high demand, annually.

Two futures at play in regeneration

For each site, there are practical reasons why these steps are different. In part, the details of regeneration practice are a result of technical considerations. For example, the facilities at the SSV are conducive to long term storage in a way that those of the HSL are not, such that irrespective of stock depletion by seed bank users, regeneration must be more frequent. Furthermore, the expense of following formal regeneration protocol like that of the SSV or JIC, as opposed to the seed guardian model, would be too great for an organisation like the HSL. However, another key factor is at play.

My argument, here, is that the most influential driver of temporalities in each seed banking milieu is the immediate future use to which its plant genetic resources are to be put, or, put differently, the audience which each seed bank seeks to serve. Hence, the HSL is required to regenerate its stock regularly and in a low cost way because, as a result of its aim to ensure the wide redistribution of its material, stock levels are frequently depleted. The SSV, however, does the opposite because it seeks to avoid the removal of material from its shelves unless absolutely necessary. The JIC, at which it would be technically possible for stock viability to match that of the SSV, does endeavour to make its materials available for external users, although, because of the nature of its audience, this material distribution does not lead to quite the same rapid turnover of stock levels. In short, it is the association of a seed bank with its user groups in the immediate future which directs how practices of regeneration for perpetuity take place. As such, regeneration always serves a double role.

This matters because of the effect regeneration may have on plant genetic resources. Although seed banking is a practice which aims to conserve plant genetic resources for perpetuity, the mutability of seeds as material objects means that the objects themselves are anchored in particular points in time. What I mean by this is that in any seed banking system, the SSV excluded, seeds are unlikely to be more than a few decades old; the seeds are anchored to the period they were made because their viability will decline over time. Moreover, there is no original or authentic material to turn back to in the case of banked seed. Rather, there is nothing but the current generation and, perhaps, some remaining samples of the one or two generations which preceded it. Hence, while each generation of new material made is a material preparation for a future that extends into perpetuity, it is also a material preparation for the generation to follow. It is the differing frequencies of regeneration at each seed banking organisation which affect the way perpetuity brought into being by the practice.

This is because each new generation makes possible the introduction of change. While, such as in the case of the bagged grain of JIC's regeneration work discussed in Chapter 5, there are techniques which can reduce the incidences of genetic change to levels so small as to be inconsequential over many hundreds of generations, such techniques are costly and cannot be employed in every regeneration scenario. As such, the JIC undertakes the majority of the regeneration of its grain stocks in metre squared plots in fields. In so doing, there is the risk of crossing (albeit a low risk, because the grains regenerated in this way are ones which by preference self-pollinate); there is also a vulnerability to seed quality reductions as a result of unfavourable conditions, such as drought. These circumstances are likely to be reflected in the regeneration of materials for the SSV by donor organisations when the time

comes for regeneration to be done. At the HSL, where regeneration is more frequent and undertaken in a less controlled fashion, the effect has the potential to be even greater. Even, as was noted in Chapter 5, open pollinated varieties are generally regenerated on site by experienced practitioners rather than being issued to seed guardians, unwanted crossing or unfavourable environmental conditions may still lead to the introduction of unwanted genetic change. At all sites, even the most careful of regeneration practices is unlikely to produce a clone of what went before, and as such, each new generation of seeds is best regarded as an extremely accurate approximation of the generation which preceded it, not an exact replica.

Doing seeds in the future

In this section, I draw together the work undertaken in the earlier parts of this chapter, by turning to two examples in which banked seed material has been utilised in research projects located in food security centred settings. In doing so, my aim is to explore the outcomes of the preparedness practices in the preservation of plant genetic resources, where, thanks to their having been preserved, they are available to be utilised in the future with the intention of bringing about improved food security scenarios. As such, I have framed these examples – somewhat paradoxically given they are based on events recorded during my fieldwork – as futures; suggesting them to be instances brought into being as a consequence of seed banking practice that was undertaken in the past. The framing of these instances using the terminology of the future is not, in this case, the temporal and rhetorical impossibility it might first appear. This is because seed banking is not a new practice. Rather, as I noted in Chapter 2, is one which has been underway, in forms very similar to those employed today, for some decades now. As such, the events I recorded in the present when undertaking my fieldwork are to be understood as events that were at one time

of the future when preparatory practices of seed banking were being undertaken in the past.

The two examples of banked seed utilisation I examine here are research programmes, each investigating possible adjustments to agricultural practice in grain production with a view to enhancing food security. My aim in examining these two research programmes is to consider the ways by which futures are brought into being as a consequence of the practices of preparedness undertaken in seed banking. Put differently, what I seek to do is offer an examination of the kinds of outcomes that might occur due to the utilisation of plant genetic resources for food security. Critically, what I will show through my case studies and supporting study, is that seed banking does not intrinsically set up or bring into being specific futures, rather it makes a general set of futures possible. Principally, having a reservoir of plant genetic resources makes it more possible to bring about genetic change in future agricultural crop plants; making available a reservoir of traits and combinations of traits (Fowler, interview, 8 November 2011) which can be bred into food producing plants with the aim of making that part of the food system more food secure. Significantly, simply having access to plant genetic resources does not direct how they are employed in such work; there is no compulsion to use them, and neither are limitations placed on what can or cannot be done with the conserved materials. This is because the kind of preparedness brought about by plant genetic resource preservation is not one specific toolkit for one specific job, instead it opens up the possibility of undertaking a diverse range of jobs. By banking seed, options are kept open.

This creation of open options is fundamental to the enactment of preparedness in the form I described it in the introduction to this chapter. Future changes in

agriculture centred on food security will, almost certainly, be driven by a general aspiration to increase productivity combined with a need to respond to changes in growing environments linked to wider environmental change. Achieving this will, in turn, almost certainly require access to a bank of plant genetic resources. In both the examples examined in this section, climate change is cited by the projects' investigators as a core reason for undertaking their research. As such, in retrospect, past work of plant genetic resource preservation is understood as act of preparation for climate change. However, at the time at which that preparation is underway, there is a great deal of uncertainty. Although it is thought almost certain that plant genetic material in general will be of utility in future, what is not known is which samples will be of use, how they will be used, or what reasons will justify their use. This is because future needs cannot be known in the present. So, while in the case of the examples in this section, climate change is framed as a central driver for plant genetic resource use, the plant genetic resources themselves were never conserved with a view to their employment in such a scenario. Thus, I argue that the preservation of each individual sample is kind of preparedness undertaken with a precautionary inflection, because, at some unknown point in future, there is a possibility that it may be useful.

The two case examples which follow are demonstrative of the functioning of preparedness that preserving seeds engenders; one of maintaining openness but not knowing how it might be utilised in the future. The examples illustrate two research projects. They are undertaken in ways methodologically and ideologically distinct from one another, and enmeshed within each are two very different purviews of possible future agricultural practices intended to bring about food security. Yet, importantly, in spite of these differences each project makes use of material stored at the JIC. The effects of preparatory nature of

seed banking by that institution is made clear by the very fact that materials were available with which to undertake this research. Additionally, the openness such preparedness has brought about is demonstrated by the diversity of material that was available, the range of samples preserved over decades by that organisation even though, at the time of their preservation, this use to which they have subsequently been put could not have been foreseen.

Experiments at the John Innes Centre

In addition to ethnographic work at the JIC's seed store, I undertook a comprehensive interview with plant researcher in the organisation, Dr. Simon Griffiths. Griffiths is the Project Leader of the 'Griffiths Group' in the JIC's Crop Genetics laboratory and a specialist in the genetic enhancement of wheat. He is a contributor to the Wheat Improvement Strategic Programme or WISP, a six year project run across five institutions between 2011 and 2017, funded by the Biotechnology and Biological Sciences Research Council. The project seeks to "produce new and novel wheat germplasm characterised for traits relevant to academics and breeders and will identify genetic markers for selecting these traits" (WISP). The project is what is called a pre-breeding programme, a programme which seeks to identify and develop materials and knowledge intended for incorporation into conventional agriculture. Griffiths leads the Landrace Pillar²⁰, and in this role is examining material from the JIC's landrace collections, those being the collections of old wheat varieties which predate contemporary agriculture. Such work is needed because, as Griffiths explains, there is a shortage of novel variation available for inclusion into new wheat varieties:

I think a breeder would hate you to say this but there's a little bit of

²⁰ This is the same project which was examined briefly in Chapter 1 of this thesis, in the context of the methodological advances of marker assisted selection in plant breeding.

truth in it. [In most current wheat breeding] they [the breeders] cross the best with the best, and they take the best and throw away the rest. So you take two varieties that are very adapted to UK conditions and the kind of things that are here, you make big families, and select the individuals which deliver the goods. And by doing that over and over again, there has been a steady progress in yield. But not just yield, in disease resistance, in the quality of wheat for food processors who want to use it. But ... as time goes on, in the UK and globally, genetic gain gets harder and harder to achieve. It's a law of diminishing returns. If you just keep crossing the best with the best, you're shuffling combinations of genes but you're not getting anything new in there. ... So the fundamental question for us is, how do you accelerate the good stuff from [material such as landraces] that you haven't got in what farmers grow at the moment in whatever the type of environment it is? And how do you move that to those varieties? That's what it's all about. (Griffiths, interview, 11 March 2011)

At the time of interview, the project was in its very early stages, funding having been secured only weeks beforehand. However, as the interview progressed, Griffiths outlined the techniques to be used to produce the pre-breeding material, and how that pre-breeding material created may later be taken forward by plant breeders. First, landrace varieties must be grown out in an effort to identify those with traits of possible utility:

So the way we're doing it is. Well, if a breeder makes a cross with a landrace and looks at the progeny, generally he's [sic] going to be very disappointed because everything's going to look worse than his good parent. But you can use genetic approaches to break up the variation

that you're seeing and say where it comes from [and this is what will be done in this project]. It's called Quantitative Trait [Locus] Analysis or QTL analysis. And you'd say okay, in this family [the large number of individuals in this generation] that developed from the good line crossed with the landrace there's these QTL; and we can see these beneficial QTL most probably from the elite variety, but there's also these other QTL which seem to be coming from the landrace. And once you've got that handle on them [the QTL from the landrace], that genetic handle on them, you introgress, you move that gene specifically. So what you're going to say is, 'I'll specifically select for that gene, I'll keep crossing it with that good variety'. It's not GM, it's Marker Assisted Selection of that gene into the good variety. [To clarify, the gene is the 'marker', and the good variety x landrace cross that was produced earlier is repeatedly crossed with the original good variety with the presence of the marker confirmed after each cross. After several generations a variety is created which is very similar to the original good variety but which also includes the trait obtained from the landrace.] This has worked really well for things which are easy to tag, like major genes for disease resistance. It's a bit more subtle for things which affect complex traits like stress tolerance, or yield, or nitrogen. But we think it's doable and we've got good evidence from our collaborations with commercial breeding programs where we're moving about the genes that they've already selected, that it's going to work.

(Griffiths, interview, 11 March 2011)

In other words, conserved as a result of preparedness based seed banking practice, materials of the past were folded into a future in which they could be used in efforts to bring about one possible version of a food security scenario.

Had seed banking not been undertaken, those QTL would not have been available for investigation, and so in that regard, the banking of seed kept options open. However, within the maintaining of open options is a great deal more complexity. Two situations serve to demonstrate this, one technological and one socio-political, which are outlined in the following sections of conversation with Griffiths. First, the technological:

It's an interesting one because people could have made these populations way back. You could have done this in the 70s. But you couldn't have done anything with them because in order to see the genes you need molecular markers all over the chromosomes. You make genetic maps of all the populations, and a map that allows you to say that it's this [particular] bit of the chromosome that's doing something good. So the other thing that allows you to say- we talked about the driver of food security, but technologically ... the data point cost of sequencing has just gone right right down. And basically, making a map, either directly or indirectly, you're sequencing the genome. Not all of it, you're sampling sequence and you're making a map. The cost of doing that has got low enough that it was worth making these populations because we knew we could make the maps. In fact we are taking old populations that we'd already made and putting the maps onto them as well. So it was a missing piece in the jigsaw. Geneticists in the 1940s could have told you everything I've told you, but just conceptually, in theory, it's being able to make the maps cheaply and quickly so we can exploit the populations.

(Griffiths, interview, 11 March 2011)

Seed banking, therefore, kept open the possibility of a technical development,

in this case, genetic mapping, which, when the materials were banked, did not even exist conceptually. Even as time passed and genetic mapping technologies came about, the fact that it was prohibitively expensive still left the kinds of uses to which the material is now put as hypothetical futures. Seed banking thus prepares for technological shifts which can bring about new uses to which the material may be put. The second point, illustrated by two segments of interview material, references socio-political drivers of the research process.

OZ: So getting a picture again of the scene in the UK, this stuff [the searching for useful traits in old material such as landraces] isn't happening continually. Is it in bursts, say?

SG: That's absolutely right. Some happened in the past, but in the past twenty years in the UK it really has not happened. And the reasons for that are because as far as cutting edge excellent science goes, doing this stuff would be considered run of the mill and derivative. It's [also] very long term ... And that's one of the problems we've got [because funding for long term speculative projects without grand headline impacts is hard to come by]. So we've been lucky. The BBSRC has really bitten the bullet on this one, 'we're in it for the long term and we're going to fund you to do it,' [they said]. But it's tough because there's not going to be- at an early stage, high level papers aren't going to come flying out.

...

OZ: Twenty years ago this would have been unthinkable; so what's changed now?

SG: The impetus politically, which [is] a positive one rather than a negative one, [is] the need to address global food security. So that's where BBSRC are coming from. A realisation, I think, that the UK does have to be competent in agriculture, and it does have to carry on this

genetic gain that has [already] occurred.

(Griffiths, interview, 11 March 2011)

The openness of seed banking also prepares for a future in which socio-political changes, such as the decision to address food security and to do so by offering research funding in a particular way, can enable projects to be undertaken in a manner which, as Griffiths puts it and I quote back to him in my question, would have been “unthinkable” in the recent past. Through seed banking practice, a great diversity of future possibilities are rolled into that work with materials of the past.

In sum, what is demonstrated here is the complex set of outcomes may result from the folding together of present and future in the practices of the present. The banking of wheat seeds in the JIC's seed store resulted in more than just a stock of seeds being available for an uncertain future use. The act of banking seeds engendered openness, it meant that there was material available that could be utilised in the context of a changing and unpredictable future of technical and socio-political change. However, while the case study indicates the range of possibilities that seed banking offers to conventional agriculture, it is also worth noting that the future of agriculture is unpredictable. It may not simply track neatly on from today's conventional routes. As the second case study will show, seed banked as an act of preparedness can also facilitate change in more novel directions.

Trials at the Organic Research Centre

Based at Kintbury, a few miles from Newbury, the ORC is an institution which undertakes research into organic agricultural production. Like the HSL, the ORC is a charity rather than a receiver of core government funding. In the past, a

significant portion of its income has come from research grants issued by government agencies, yet the shift to the food security agenda which was so instrumental to the arrival of new research funding at the JIC has come in parallel with a reduction in money for organic agriculture. My interview participant was Dr. Thomas Döring, the ORC's Principal Crops Researcher. Döring specialises in the effects of biodiversity, both in the crop itself and in the agricultural environment at large (ORC, undated). We spoke specifically about research undertaken at the ORC with which he was heavily involved. The project under discussion, like the project described above at the JIC, entailed making use of older grain varieties, particularly farmer selected varieties and landraces, in order to investigate possible new ways of engendering food security. Similarly, too, the project had an investigative research focus rather than being undertaken with the aim of producing material of immediate use to growers. Finally, also similar to the JIC's research, the ORC project aimed to make use of the novel traits in old varieties that might confer resistance to or tolerance of suboptimal growing conditions that lead to reductions in yield.

However, the precise aims of the research at the ORC were different. Where the JIC wanted to identify useful traits for incorporation into conventionally bred plants, the ORC's research sought to query the very agronomic foundations underpinning the JIC's research agenda. The aim of the ORC was to examine the efficacy of what are termed composite cross populations (or CCPs) in organic production systems (a literature review of research on CCPs was produced by Dr. Döring's predecessors at the ORC, Phillips & Wolfe, 2005). A CCP is the antithesis of the highly stable variety system that conventional agriculture is based upon, and has been for several decades. In a CCP, each crop is made up of a highly genetically diverse population created by the mixing of several varieties. This is predicted to confer benefits to the crop as a whole,

largely by way of resilience to environmental conditions due to traits brought about by the diverse genetic make up of the population, reducing the need to resort to water or apply inputs of herbicides, pesticides or fertilizers. In my interview, Döring explained how the varieties were selected to make up the CCP:

[T]hey were very targeted selections. And as far as I know the only criterion, or the only two criteria, were first of all that they had a large area over which they were grown, and [had been grown for] a long time. So basically, at their time, successful varieties that many farmers would grow. Also, a second criterion, was that basically the use of varieties, whether they were used for bread making or as feed varieties [those grown to feed animals], with a higher yield potential. So three populations were created, one only from the feed varieties, one from the quality lines [for bread making], and one from both. And I don't know whether it was actually, in the end, a deliberate criterion for selection of the varieties, but it seems in, at least in hindsight, that what we selected – or what was selected at the time – provided the pedigrees of basically all common European varieties that were grown from, let's say, the 1940s and 50s onwards. So they contain all the genetic background of everything, basically. That's what the breeders at the John Innes centre tell us.

(Döring, interview, 13 June 2011)

As at the JIC, the practice of preparedness in the preservation of plant genetic resources made possible a future where novel research could be undertaken in ways unknowable at the time of the banking of the materials themselves. As at the JIC, the call for such research was centred on the necessity of

experimenting with new versions of agricultural production to ensure food security in the light of predicted environmental change and the effects it is thought likely to have on existing modes of agriculture:

The motivation behind the research? Yeah, I think there are several thoughts. One is that in, I don't know exactly when it started, but 20 or 30 years ago, there was a lot of research on variety mixtures where a lot of [conventional, stable] varieties were mixed [at a landscape scale] and you could see benefits to yield, disease reduction and so on. And that somehow failed to be taken up by the industry, despite the proven success. But it's still actually- mixing varieties is still part of recommendations by NIAB, for exactly- for rust control. But the idea was, now this is not enough diversity, we need still more diversity. And building on previous research on crop populations, the idea was to create much higher diversity and to basically to boost the benefits that were seen in variety mixtures. So that's one motivation. But perhaps more important is the question of environmental variability that really was coming onto the agenda with climate change. So, basically, it's known that both theoretically and from experimental evidence, that if you take more than one genotype into your mixture then you've got better protection against environmental fluctuations, and higher stability. And that effect is stronger, or is more important, if your environment tends to fluctuate a lot. [...] So basically, the diversity [in the crop growing] provides some insurance, so the more diversity you have the more insurance you have and the higher the range of environments that the crop can deal with. [...] This is particularly true if seeds are collected and resown year on year.] If that evolves on the site where it's grown, it has

the potential to adapt to the site where it's grown.

(Döring, interview, 13 June 2011)

The aim of the ORC's project is to experiment with an alternative way to bring about food security which makes use of preserved plant genetic resource material but which does so, as was demonstrated in Döring's outline of the project's justifications and specifications, in a way which contrasts heavily with project undertaken at the JIC. Through examination of the two projects, I have show the utility of the preparedness centred approach to plant genetic resource preservation, showing that preserving plant genetic resources in this way ensures the availability of materials which allow a diversity of futures to come into being. As argued in the previous two sections, the banking of seed is a practice which folds materials of the past and future together through acts undertaken in the present. However, it does so in a way which does not dictate the form those futures come to take. Rather, seed banking for food security is a technique which keeps options open, and which makes possible a range of futures in which change is responded to.

Conclusion

In this chapter, I have made two interrelated assertions. The first surrounds the notion of food security and its framing, not as a state that can be achieved, but as a process always on the way to becoming. I have argued that seed banking acts as an exemplar of that notion, by examining it both conceptually and in practice. The second assertion surrounds the way that the practice of seed banking works in the process of food security. Through the employment of concepts of temporality, my contention has been that seed banking operates as a practice of preparedness, in which work is undertaken in the present with a view to bringing about future scenarios where food security related practice

may be more effectively undertaken. The argument, which was illustrated with a range of empirical material, was constructed in layers. I began by showing how the concept of seed banking was one currently premised on the preservation of plant genetic resources in order to prepare for future food security related activities. Then, the way seed banking does preparation was explored in practice, through discussion of acts of seed material regeneration at different seed banks. Finally, a seed banking future was explored, in which two food security based research projects were contrasted.

In making the two key assertions of this chapter, I have built on the conceptual argument developed in Chapter 5. In that chapter, I contended that plant genetic resources were the material outcome of practices undertaken on and by seeds enmeshed in seed banking milieus. Though, as it was demonstrated, there is no singular way to bring about plant genetic resources, the different versions of plant genetic resource that are brought about due to the various ways they are practiced still hold together as a coherent object; in other words, plant genetic resources are multiple rather than plural. The work of this chapter is demonstrative of the importance of that coherency. Though multiple, the fact that plant genetic resources still work in a consistent and orderly way is integral to their functioning in food security related scenarios. This is because they are able to perform in a unified and stable fashion in different scenarios, rather than their employment being limited by the seed banking framework in which they became plant genetic resources. This was demonstrated in the way that material from the JIC was as useful in research in the milieu of conventional agricultural science of the JIC's research centre as it was in the alternative and counter-mainstream setting of the ORC.

Having ascertained how seed banking works to bring about plant genetic

resources, and considered how those plant genetic resources operate in food security milieus, in the following chapter I turn to consider the way politics is enmeshed within each of these activities.

Chapter 7: Seeds politics

Introduction

In this chapter, I examine the roles seeds play as active agents in seed bank settings. Drawing from the contentions about material agency made in Chapter 3, the chapter considers how the notion that “matter matters” (Barad, 2003, p. 803) plays out in the framework of this research. I do so because attending to how seeds function as agentic actors enables comprehension of the way they “make a difference” (Law & Mol, 2008a, p. 57) to the milieus of plant genetic resources and food security in which they operate. However, being attentive to materiality, as I argued in Chapter 3, must do more than undertake just a “shallow engagement” with only the “surface” of materialism (Tolia-Kelly, 2012, p. 1). As such, this chapter also contends that such agency is of political consequence, and the notion of seed politics is developed.

The chapter is made up of three sections, each of which performs two tasks which I set out here. First, the sections are ordered such that they develop, in a successive fashion, a broad argument for a version of seed politics which has attention to materiality at its heart. In other words, by undertaking this first task, my intention is to make the assertion that materiality is important in the understanding of the practices and politics of seed banking increasingly firm as the chapter progresses. Second, each section explores a different version of seed politics. This I do in order to demonstrate there to be a multiplicity of ways that this materiality may come to matter.

In the first section, I open the case for seed politics by considering it through

the framework of actors enacted (Law & Mol, 2008a). I examine how the biology of seeds was agentic in the quotidian practices which led to the formation of a seed banking infrastructure and, relatedly, a broader plant genetic resources milieu. This is developed by exploration of how seed biology has also contributed to the shaping of the contours of its present functioning. In the second section, I build upon that argument for material agency in seed politics by demonstrating its role in a specific political event. When a change in the legislation governing the distribution of heritage seeds was proposed, one which made possible the commercialisation of heritage varieties, it was the materiality of seeds as well as the legislation itself which was thought likely to direct the possible consequences that this change to the legal framework might have. In the final section, having argued that materiality does play a foundational role in seed politics, I examine the consequences of that argument by considering what it might mean to do good seed banking, or, in other words, to bank seed well and in a way beneficial to food security.

Seeds as actors enacted

Following established arguments for the recognition of the agency of materials outlined in Chapter 3, in this section I shall demonstrate how this agency plays out specifically in the case of banked seed, showing those seeds to be actors enacted (see Law & Mol, 2008a) in the formation of what has since come to be the plant genetic resources milieu of the present. In making that argument, I shall explore a version of politics attentive to quotidian practice (Law & Mol, 2008b). By examining the biological workings of both seeds and the mechanisms of their production by plants, later exemplified by consideration of modes of plant reproduction which do not follow the usual model, I shall show how these materialities worked and continue to work to shape the contours of, and techniques for, the preservation of plant genetic resources. Seeds are

actors enacted, I shall argue, because they are not only made into plant genetic resources, as I showed in Chapter 5, but their materiality makes the notion and framework of plant genetic resources possible.

The materials of seed banking

The materiality of plant genetic resources is an outcome of the evolution of the plant reproductive system (on which see Kessler, Stuppy, & Papadakis, 2009). Over time and due to selection pressure, seed production has evolved to be the predominate mode of reproduction in plants. Because plants are able neither to move from the environment in which they grow, nor can they – individually or over short periods – modify that environment in any significant way, seeds act as a safe storage vessels for plant potentiality, realised only when the environment and location they find themselves in is suitable. Seeds are living organisms and cannot maintain their viability indefinitely. To prolong that viability, seeds respond to reduced temperature and moisture levels immediately unsuitable for growth by slowing their metabolism and becoming dormant. When conditions seem suitable for plant growth, detected by seeds in factors such as light, moisture and temperature, they recover from their dormancy which may have lasted between a few months to as long as several decades or more. As such, and echoing the discussion in Chapter 6, seeds let plants travel in time, enabling germination at the moment most likely to result in the successful growth of the new generation. Further, seeds allow plants to travel in space. Because spatial diffusion is biologically advantageous, different techniques have evolved in plants for seed mobility depending on the character of their usual habitat. These include mechanisms which enable travel in wind or water, or by encouraging animals to act as vectors of seed movement such as through fruit production.

As such, the physical make up of seeds is one adapted to dealing with the kinds of pressures engendered by temporal and spatial diffusion. Yet, even in conditions favourable to germination, the chance of a wild seed growing into a full sized plant is low. Young plants are frequently outperformed by their neighbours, or suffer fatal damage by weather conditions or the actions of animals or insects. Because the investment required from a plant to produce each individual seed is relatively low, and the risks that individual faces that prevent its growth into an adult plant are relatively high, most plants create favourable odds by producing a large volume of hardy seed whose germination rate is good. These adaptations are crucial, as it is upon the basis of these that the concept of plant genetic resources emerged, as well as directing the form and practices which that seed banking went on to take.

An understanding of these features of plant and seed biology offers a backdrop pertinent to the debate, outlined in Chapter 2, between *in situ* and *ex situ* conservation techniques. For, put simply, it is those seed characteristics described above which made even the very framework of such a debate possible. Had most plants not evolved to reproduce in the manner they do, to produce relatively small and hardy seeds designed for prolonged viability in conditions easily and cheaply replicable by people, *ex situ* conservation in its current form would not have achieved the ubiquity it now has. Seeds, therefore, have been and continue to be actors in the enacting of seed banking practice (see Law & Mol, 2008a). The debate between *in situ* and *ex situ* conservation techniques, was, and indeed still is, a heated political conversation. The debate is framed around how best to undertake preservation and included, in the ways explored in Chapter 2, both biological arguments (Vellvé, 1992; Veteläinen et al., 2009) and sociocultural ones (van Dooren, 2009; Pistorius, 1997; Vellvé, 1992). In the end, it was decided (in the 1970s)

in large part as a consequence of the materiality of seeds. In short, it was because the adaptations which so successfully prolong seed viability in wild conditions are ones easily, cheaply and reliably replicable by humans, that *ex situ* banking became and remains the preferred choice in the seed and plant conservation setting.

Seeds, genes and plant genetic resources

However, seed banking for whole plant conservation as described above, by which I mean the continuing ability to regrow a whole plant in the form it was previously grown in, is not the only outcome of seed banking. Seed banking also enables the formation of a plant genetic resources milieu in which access to the genomes of varieties conserved is made possible. As outlined in the discussion of MAS in Chapter 1 of this thesis, this is presently very important. Furthermore, its importance will continue to grow over time, which is why, in Chapter 6, Fowler is cited as having made reference to seed banking as a "repository of traits and relationships and combinations" (Fowler, interview, 8 November 2011). The emergence of a seed banking system which conserves seeds as plant genetic resources is made possible by the fact that seeds act in ways which makes them effective and useful in such a system. As well as being suitable for storage over relatively long time periods, seeds reliably harbour the genetic material that enables either the replication of a whole plant, or, from which useful traits can be extracted and bred into other plants by both conventional breeding techniques or genetic modification. The only way to know for certain the genetic make up of a seed, to ascertain the traits it carries, is to grow it out (which, inevitably results in the sample's destruction). However, based on a knowledge of the parent plants, one can usually be all but certain of the genetic make up of a seed and, likewise, can predict how it will express itself in a future growing plant. That plants and seeds reliably act in this way is

essential in the functioning of plant breeding facilities, but also for seed banks acting as a tools for saving coherent varieties or as vessels for novel genetic material. As such, seeds are, I argue, actors in the formation of an effective system of plant genetic resources conservation.

As before, the reason for this relates to the reproductive function that seeds serve for plants, as well as, more broadly, the workings of sexual reproduction in most species. To take the latter point, since Mendel's experiments with peas (see Griffiths et al., 2000), the way sexual reproduction transfers traits from one generation to the next has been well understood. Sexual reproduction is, in most cases, an act whose outcome is the introduction of genetic difference within a framework of broad intergenerational similarity. Sexual reproduction enables the creation of new mixtures of traits and offers a means for those traits which are in some way advantageous to existing individuals or populations to be passed on to future generations. So, in most cases (although not all given many food plants are self pollinating) a plant will produce new generation which, certainly genetically although at times phenotypically, differs at least slightly from that preceding. However, this is not useful in a plant genetic resources milieu where an infrastructure of naming and the accumulation of data on those named varieties, in ways discussed in Chapter 5, exists too. As such, while the fact that seeds carry genetic material from one generation to the next is essential to *ex situ* seed banking, if that genetic churning is allowed to take place unchecked its utility is effaced. However, as also discussed in Chapter 5, humans can influence this plant practice in ways which improve its suitability for the plant genetic resources milieu: at the JIC, in some cases grain is bagged to make the risk of cross pollination negligible; at the HSL open pollinated varieties are grown out in mesh tunnels with introduced pollinators to prevent undesired cross pollination; and, finally, HSL

seed guardians avoid open pollinated crops because purity is difficult to achieve. In short, the mode by which plants transfer traits between generations may be employed and modified by people so that it best suits the requirements of each particular plant genetic resource preservation setting.

Materialities disrupted

The role these materialities play in enacting seed banking, in shaping its practices and in so doing being part of the articulation of its politics, are almost imperceptible when working as expected – akin to the Latourian black box (Latour, 1987). As such, the fact that seed banking neither inevitable nor universal may be easily sidelined. However, due to their material makeup not all seeds may be banked; and it is when assumed practices are disrupted by materiality that the centrality of that materiality to seed banking practice draws most clearly into view. I shall demonstrate this argument with reference to two examples. The first is the case of recalcitrant seeds. Recalcitrance is a term applied to seeds which, for various physiological reasons, do not exhibit the characteristics that allow orthodox seeds, the term applied to ordinary, bankable seeds, to be conserved in a standard seed banking milieu (see also Berjak & Pammenter, 2008; Roberts, 1973). The second example considers cases where either no seeds are produced or where the seeds produced are, for reasons other than recalcitrance, unsuitable for incorporation into a seed banking regime for the conservation of their plant genetic resources. Through consideration of the effect such materialities have on the conservation of plant genetic resources, the agency of orthodox seeds is drawn into sharp focus.

Recalcitrant seeds are unsuited to storage in seed banks because they cannot tolerate desiccation. The desiccation, or drying, of seeds is undertaken prior to their being stored at low temperatures – the standard in seed banks is around

-18 degrees celsius – because unless removed that moisture freezes and forms ice crystals which damage cell structure (Fry, Seddon, & Vines, 2011, pp. 42–43). The mechanisms causing this desiccation intolerance in some varieties' seeds are poorly understood, particularly as in most cases it not a consequence of one single factor. Disruption of metabolic processes due to the reduction of water content is thought to be one cause, and actual cell damage due to the removal of water needed for cell architecture the other. That said, either cause may come about due to one or several of a number of different physiological responses (Vozzo, undated, p. 147). In other cases, although it may be possible to conserve the seeds of a food plant using conventional seed banking techniques, to do so would be of little utility as the offspring would bear little resemblance to the parent generation. Apples are one example of a widely consumed variety which produces seeds of this type (Brown & Maloney, 2003, p. 32; Juniper & Mabberley, 2006, p. 92). This is a consequence of the species' tendency for what is termed "extreme heterozygosity" (Pollan, 2002, p. 11). The consequence of this extreme heterozygosity is that, rather than containing recognisable traits from each parent, in each generation there is turbulent genetic mixing. Offspring are unlikely to have more than a minor resemblance to the parent line, and as such the storing of seeds confers little or no benefit in the preservation of usable plant genetic resources.

The alternatives to seed banking include *in vitro* conservation, or the storage of a sample of living plant cells in a test tube; cryopreservation, or the storage of a sample of plant cells at the extremely low temperatures brought about by a substance such as liquid nitrogen; or field gene banking, which is the maintenance of a growing sample of plant material in field conditions and is the technique used to conserve apples. Although these techniques exist, they are not preferred, being regarded by the International Plant Genetic Resources

Institute as being “more expensive and less reliable storage methods” than seed banking (Engels & Visser, 2003, p. 29).

In this section, I argued for a recognition of the day to day politics of seed agency (in the way called for in Mol, 2002, p. 169). This was done by examining the material agency of seeds and showing them to be actors enacted (Law & Mol, 2008a) in the formation of the present seed banking milieu. I now develop that argument by considering how that agency is operates in the case of a version of politics which comes about in a moment or event which disrupt the quotidian (Barry, 2001, 2010).

Commercialisation of heritage varieties

At the time of my fieldwork, just such a moment or event was underway. A consultation had been opened on a proposal to modify the legislation governing the commercial exchange of seed. This modification, which was eventually implemented in full after my fieldwork was completed²¹, was intended to enable the commercialisation of heritage²² varieties in seed form. Though the law has always permitted the sale of heritage varieties as growing plants, the sale of heritage seeds had been prohibited as an unintended consequence of rules instigated several decades ago in order to control the quality of seed destined for use in intensive commercial agriculture. In short, these regulations were

21 As such, the analysis in this section addresses the expected outcomes hypothesised by respondents to Defra's consultation, not the outcomes of the change in legislation itself. For further discussion of methods, see Chapter 4.

22 In the thesis up to this point I have used the term “heritage” seeds, largely because this is the term used by the HSL. In the documents related to this case, the terms “amateur” and “conservation” varieties are used, as well as the term “landrace”. In this section, the terms may be understood as interchangeable, as their purpose is to solely reflect these varieties' disconnect from seed used in commercial agriculture.

written at a time when heritage varieties were widely considered obsolete or irrelevant, and as such failed to differentiate between the different requirements and standards of mainstream and heritage seed markets.

The analysis in this section is centred on responses submitted voluntarily by various interested parties as a result of an open consultation to this proposed change to regulation. What I shall derive from the consultees' responses and my analysis of them is a sense that the legislative change might risk disrupting the equilibrium which had developed within the previous regulatory framework between the material and human agencies underpinning the regimes of heritage seed supply, conservation and use. In short, by implementing aspects of a commercial approach in a previously conservation centred milieu, practitioners who responded to the consultation predicted deleterious conservation outcomes for those varieties. In this section I explore how these practitioners thought this might come about, considering first the effects of the administrative practices of seed listing and, later, naming which the new legislation compels heritage seeds to be involved in, before moving on to consider how practices of conservation and commercialisation abut one another.

The effect of seed listing

Excluded from mainstream regulation, and without alternative regulation in place, for several decades the exchange of amateur vegetable varieties in the UK occupied a kind of legislative no man's land. European Union law prohibited the commercial exploitation of seed, irrespective of quantity, unless officially registered through the national listing programme. As such, distribution of unlisted heritage varieties was limited to non-commercial seed swapping events and through organisations like the HSL²³. Though not its intention, by its very

²³ The HSL is a charity whose members are entitled to receive seed samples of heritage varieties as part of their membership. As such, the HSL does not technically sell its seeds.

nature, listing excluded amateur varieties. The measure was introduced as a means of quality assurance and commercial protection for conventional farmers who make large investments in seed. Exclusion from listing was partly a pragmatic decision by those handling amateur varieties. Distributors, such as the HSL, could afford neither the scheme's administrative fees, nor the large volume of sample seed required by the scheme. Amateur varieties were also excluded on technical grounds. National listing requires the variety in question be demonstrably distinct from any other, that all the plants of that variety are sufficiently uniform, and that the variety is stable over generations. In regulatory shorthand, this is known by the acronym DUS (Distinctiveness, Uniformity and Stability) (Fera, 2010, pp. 8–9). Because of the effects of open pollination, a lack of standard parental line, and informal naming practices, amateur seeds would fail DUS testing. While the old legislation did not lead to the disappearance of these varieties, it did unintentionally set the parameters through which these seeds were exchanged, used and conserved. The aforementioned equilibrium of human and nonhuman agency came about in this setting.

The proposed change to legislation sought to remove the block on varieties unsuitable for mainstream agriculture, those failing DUS tests, being made available to consumers through commercial channels. In other words, it sought to occupy what I earlier termed the legislative no man's land. This policy makers aimed to achieve through the instigation of a new and less prescriptive listing regime suited to the materiality of amateur varieties:

The overall aim of the Directive is to promote the sustainable use of plant genetic resources, that is traditionally grown varieties and landraces and varieties of 'no intrinsic value for crop production but

developed for growing under particular conditions'. In practice, this means encouraging the marketing of conservation (or heritage) varieties and of varieties intended specifically for amateur gardeners. It aims to do this through simpler requirements, giving a cheaper and quicker route to National Listing and minimising seed production costs.

(Defra letter to consultees, August 2010)

Absence was as important as presence in the emergence of a seed banking practice shaped by disassociation from the requirements of the prevailing legislative regime. However, a legislative shift, an event in the political landscape of seed banking, was to lead to that disassociation, that absence, being removed and, consequently, disruption to seed banking practice. In the following section, I will examine the outcomes expected by practitioners as a result of this event. In so doing, I will show seeds to be agentic materials in the unfolding of the event, actors enacted in the regimes within which they exist.

Names doing work

As I showed in Chapter 5, information forms a key plank in the making of seeds into plant genetic resources. It plays a central role in what seeds are and how they are practiced. In this section, I shall examine the practice of one of the most basic informational elements by which seeds are known, their varietal name. Through further explanation of the proposed new listing regime, and using data drawn from consultee responses, I shall argue that practice of naming may have significant, indeed political, consequences. These consequences are, as I will also go on to show in the section which follows, a result of the function of distributed agency, where seeds both act and are acted upon in the workings of naming.

As a mode of identification, names are at their most effective when each thing or category of things is named uniquely. For commercial varieties, this enables entry to national seed lists. It would be technically impossible to ensure every seed is genetically identical, but standardised parenthood and cultivation conditions in production confer general consistency. National commercial seed lists are thus populated by standardised named varieties which will exhibit, when grown, an almost certain set of characteristics: they are distinct, uniform and stable. This coordination between variety name, seed, and characteristics is reinforced by the submission of seed samples to a governmental regulatory agency (Science and Advice for Scottish Agriculture or SASA takes on this role throughout the UK). The organisation taking responsibility for the name and the submission of the seed sample, which is in almost all cases a seed breeding company, is known as the maintainer, and there can be only one maintainer per named variety. The seeds submitted to SASA are retained in cold storage for a number of years in order that they may be grown out and characterised as a performance benchmark for that variety in case a grower raises a query.

In the listing regime proposed for amateur and conservation varieties, the practices of the commercial setting are echoed: each variety is to be named and registered, and a maintainer will be required to submit a seed sample to a regulatory agency. But the coherency and stability which listing engenders, which is so suited to the commercial seed setting, is problematic when working with heritage seeds. Where, in the conventional setting, a name enables the precise definition of variety, in the amateur and conservation milieu this is not the case. This is a material consequence of the makeup and origins of the varieties themselves. Rather than having been deliberately bred, most amateur and conservation varieties have been developed informally over numerous generations. As such, although they are known by names which enable

varieties to be identified, this naming is at best informal. Materially, this is because they have neither the standard genetic make up nor the traceable lineage a conventional variety would have. Naming, and in particular the way by which it has come to play a crucial role in the knowing and practicing of seeds, is reconfigured by its practice in the proposed new listing regime for amateur and conservation varieties. And that reconfiguration matters, as these typical responses demonstrate:

Apart from the obvious problem of ensuring everything offered for sale is registered there is still the problem of *who registers what*[. F]or example, if we were to take a well established amateur variety, register it through the new scheme thereby undertaking to store the samples and pay the fee, etc., what is to stop another retail company selling the same variety because we have registered it? [...] While in principle each seed company registering their unique varieties sounds like a good idea, in reality I think there will be a certain amount of ambiguity over who should register the main 'core' amateur varieties.

(Robert Aldsworth, Manager of Moles Seeds, a small seed company specialising in heritage varieties, consultation response, emphasis added)

Garden Organic is concerned about a return to a proliferation of names. We do not believe that SASA [Science and Advice for Scottish Agriculture] has the capacity to police the new regulation adequately. Placing a sample of seed with SASA does not guarantee authenticity and descriptions for some varieties may be scant.

(Bob Sherman, Chief Horticultural Officer, Garden Organic, consultation response)

There are two key issues at play here, as these quotations demonstrate. First, practically, registering a variety will be an administrative, technical and financial burden which individual organisations will wish to avoid if its benefits are enjoyed universally. On the other hand, were each organisation selling a particular named variety to register it, the administrative burden on the registration agency would itself become prohibitive. Second, and more significantly, the issue concerns the confidence that the variety named is what it purports to be, and meets the phenotypic expectations a grower might have for that variety. For, as a named amateur or conservation variety has neither the guarantees of origin, heredity, nor phenotypic predictability expected from conventional varieties, there is scope for uncertainty. In a commercial setting this could be regarded as being disruptive or even anticompetitive as the work done by the name, the tool which enables vendors to represent their product and consumers to make purchase preferences, is attenuated. Enmeshed within both these issues is a subtext hinting at uncertainty and apprehension toward a disruption to the emerging heritage vegetable variety market which the infrastructural groundwork, popularity and trust which it holds in the eyes of the potential consumers many of the respondents can quite legitimately claim significant responsibility for having lain. Thus, names, the informational representation of a material practice, have some considerable political consequence.

Names are consequential too in the conservation of plant genetic resources, as this quotation from the HSL's response demonstrates:

[I]dentifying an exact variety allows our HSL, for example, to catalogue the agronomic characteristics and social history associated with it. Only accurate registering of varieties allows this important contribution to

effective conservation of genetic resources with accompanying knowledge.

(Bob Sherman, Chief Horticultural Officer, Garden Organic, consultation response)

The cultural affiliations a variety name carries with it have great significance to conservation work. The HSL, as was shown in Chapter 5, as well as maintaining a comprehensive material stock of genetic material, carries too a large amount of information about their accessions. Each accession, and each dataset which it carries with it, is associated with the name attributed to the variety. Disruption of the reliability of this naming system has potentially deleterious consequences for conservation practice, as the value of that information is considerably reduced by its becoming unreliable. The HSL's proposed solution bypasses the issue of naming altogether, suggesting each accession registered should instead be issued with a "unique number". Thus, the name would serve as a shorthand way for members of the public to identify the variety purchased, while the unique number could be used by those seeking reliable technical data.

Seeds doing names

As I argued above, naming is a practice which does political work. It enacts seeds, by which I mean it is a practice by which seeds are brought into being. But seeds are not passive objects in the practice of varietal naming. For while the names themselves may be imposed by humans, seeds too play a role in the practices that come of being named, and in the consequences names engender.

Echoing the debates of Chapter 6, I argue here that varietal names act as a way of folding the past and present into the future. Names represent potential; they act as indicators of the future to be brought into being by the growing of a

seed in the present, drawn from past knowledge of the characteristics of that named variety. A variety name applied to a collection of seeds is, therefore, a mode of representing a material future. I discussed above how variety names are ways by which classes or categories of seeds are created, as mechanisms which engender an inside and an outside. Although they are not visible to the eye, these boundaries are materially constructed. For, echoing the discussion of seeds and genes in the section above, whether a seed may be said to be inside or outside the boundaries of a variety is a consequence entirely of that seed's genetic makeup.

Earlier in the section I highlighted the difference between the steady and certain nature of variety following plant breeding and variety creation in a conventional setting, and the informal way variety works in the context of amateur and conservation varieties. I suggested that the practice of naming is precisely representative only in cases of the former, more ordered, version of variety. This is because, when a variety is bred in a conventional context, a high level of control is exerted over its genetic make up. Its parental lines are specifically selected and the mass production of seed is managed to ensure as little deviation as possible from the outcome required. As such, the agency of plant mechanisms by which genetic mixing would normally be brought about is effaced, and instead the genetic outcome is all but predetermined by the human selected parental crosses. It would certainly be inaccurate to suggest that in amateur and conservation varieties that human agency is irrelevant. It is not. However, plant mechanisms are afforded greater agency in the genetic mixture of the seeds they produce. As such, while of course naming still takes place, the genomes of these named varieties incorporate far greater genetic diversity than do conventional varieties because their breeding is not so rigidly controlled: first, because they are often open pollinated there exists greater

scope to incorporate new variation; and, because in many cases each year's new seeds are created from the growth of the generation before (this is particularly the case seed swap events and organisations like the HSL) rather than there being original parental crosses to return to (in the way outlined in Chapter 6), the genetic makeup of a variety has greater propensity to shift over generations.

Therefore, it is in this way that I argue seeds to be participants in the practice of names. For although neither seeds nor the plants that produce them have intentionality, the biological processes undertaken by seeds and plants has an effect on the way that naming is practiced. The usual outcome of sexual reproduction is an incremental increase in genetic diversity over generations. But that increase of diversity is undertaken in a context where human practices seek minimisation of that intergenerational change. The practice of naming amateur or conservation varieties is a coordinated effort of plants and humans. Human practices work toward the production of a new generation that is the same as the current one, or at least not too different. Plant practices, in open pollinated plants at least, work toward the production of a new generation that is different to the current one, or at least not too similar. Thus variety naming in a heritage context is dependent on a balance between a pragmatic assessment by humans of how much intergenerational difference their use systems can tolerate and a biological tendency of plants to bring new diversity to their gene pools.

Thus, if names are political, seed agency in the practice of those names has implications for that politics. As I noted above, names are central to the commercial practice that the shifting seed legislation sought to bring about. It is through names that varieties are entered onto seed lists, and, further, names

play a significant role in the engagement of consumers to be purchasers of seeds as products. As such, these politics must be regarded as consequences of that genetic and material tug-of-war between humans and nonhumans in the way outlined in the paragraph above.

Commercialisation and conservation

Without exception, all consultees welcomed, if cautiously, the proposed regime. The bulk of respondents were seed vendors who supported the relaxation of the rules which would either facilitate their entrance into a new market or offer legitimacy to their work in one where they already operate. The principal concern of this part of the heritage seed sector was of financial burden and market wide quality assurance. However, the caution in the welcome offered by those in the conservation sector was visible both in consultees' wording – “In Garden Organic's opinion *the principle behind this new regulation* is to be welcomed,” (Bob Sherman, Chief Horticultural Officer, Garden Organic, emphasis added) – and, in the case of Paul Gilbert and Simon Platten who responded as members of the Centre for Biocultural Diversity at the School of Anthropology and Conservation at the University of Kent, in their specific statements. One key consequence sought by the legislative change was to increase the accessibility of amateur and heritage varieties by making them available on the commercial market. In other words, it sought to make an apparently immobile system, where seed distribution was considered to be constrained, into one more mobile, where seed distribution was encouraged (the importance of seed mobility will be elaborated upon in the following section). Arguably, however, by adding a new version of mobility onto that which currently existed, that being the bringing of heritage seeds into a commercial version of mobility, there emerged a risk that the informal version of mobility that had previously dominated might be attenuated. As a result, the

conservation that such a framework had brought about also risked attenuation. In this part of the section, I examine the possible conservation outcomes of the change in legislation, and consider the role of seed agency in this process.

Earlier in the chapter, I argued that the current regime of exchange and conservation of heritage varieties came about in part as a consequence of these varieties' exclusion from mainstream distribution regimes. Paul Gilbert and Dr. Simon Platten offer further commentary on the nature of that exclusion and the role it played in promoting conservation:

Current access to conservation and amateur varieties is primarily through seed 'clubs' and seed-swap events. Both of these mechanisms work around the current legislation in a manner which, to the public at least, often appears as mildly subversive. ... [I]t is clear that for many of the participating public a significant part of the attraction of seed-swap events lies in being part of a countercultural movement which seeks to highlight, and work against, the perceived dangers of market provision. (Paul Gilbert and Dr. Simon Platten, Centre for Biocultural Diversity, School of Anthropology and Conservation, University of Kent, consultation response)

Their suggestion is echoed my own fieldwork, where HSL's seed guardians voiced distrust of a perceived corporate dominance of the food system by agribusinesses and supermarket chains, as well as raising concerns about food production techniques like intensive farming, pesticide use, or genetic modification. For Gilbert and Platten there is some irony in the concern they raise. In short, a legislative change aiming to "promote the sustainable use of plant genetic resources" (Defra letter to consultees, August 2010) could result

in the opposite because as lively networks of heritage variety exchange, the mode through which conservation currently occurs, are attenuated by that exchange's regularisation. In addition, the pair also highlight a risk to the type of heritage variety conservation which becomes possible:

[A]ttempts to increase access to such plant material via the market model are likely to have deleterious effects upon the breadth of genetic diversity which it seeks to promote. ... If seed production for conservation and amateur varieties is managed by a single 'registered maintainer', and if the area of seeds that can be produced for sale is limited (as suggested in the FERA Framework Document), a bottlenecking of the genetic diversity previously contained in these varieties, when they were managed as landraces, could occur.
(*ibid.*)

Put differently, the respondents suggest that the dynamic system of exchange and mobility of seeds, a consequence of the regime of seed swaps and seed distribution through a network like the HSL's, risks being superseded by comparatively rigid regime where one or a few organisations are responsible for annually bulking up seed from a central pool of stock to provide for a consumer market. Were this to be the case, the rich genetic diversity which comes of seeds being exchanged, circulated, and grown out in numerous different environments; of new seed being produced from the previous year's plants rather than being bulked out from a standard base collection; and of there being a large number of seed producers rather than few – the reason Gilbert and Platten term these seeds "landraces" – would likely be depleted. An apparently more open system of exchange, one no longer impeded by regulation, could lead to a more closed system of seed regeneration and as

such, what are currently highly diverse varieties might, once squeezed through the genetic bottleneck of these commercial practices, become relatively less diverse.

Just as I argued in the context of varietal name changes, the possible outcome of the proposed legislation is not a solely human creation. Rather, it is a coproduction of human intentionality and material agency. The existence of the heritage seed networks in the form described demonstrates this most explicitly. For while there are cultural reasons why people become part of such networks, in order to enact their resistance against conventional food provisioning regimes to reference the example above, the method through which they exert this resistance is centred on the undertaking of practices with materials. It is not just with any materials, or indeed any seeds, that one can undertake this notionally subversive practice. It rests upon having access to and being able to successfully manipulate specific materials, namely heritage seeds. The existence of the seeds, and the fact of their being materially different to the seed offerings from conventional plant genetic resources networks, is a necessity for the functioning of the practice of mild political opposition. Further, the heritage seeds can be said to themselves act to enrol humans into these networks. For by performing the version of plant growth and vegetable production they are genetically inclined to do, they appeal to a particular group of people. Thus heritage seeds can be said to have enrolled humans who act to facilitate their distribution across space and time (see Pollan, 2002, p. xx).

However, while the genetic diversity of heritage seeds might have some success in enrolling plant growers, the convenience of commercially sourcing ostensibly similar material is likely to be more successful. For most growers, if they are aware of it at all, the additional genetic diversity of obtaining heritage seeds

through unconventional means is a happy byproduct of doing so, rather than a reason to do so. In short, while plant growers might enjoy the notion and practice of growing heritage seeds and appearing to oppose intensive agriculture by doing so, Gilbert and Platten suggest that they are less likely to extend this to efforts that help preserve genetic diversity in a more scientifically nuanced fashion that come from doing so by unconventional means.

In the final section, I draw this discussion of politics together by employing it in putting forward an argument for a way of doing seed banking well.

Doing seed banking well

The moral question is thus not, nor has it ever been: should one eat or not eat, eat this and not that, the living or the nonliving, man or animal, but since *one must* eat in any case and since it is and tastes good to eat, and since there's no other definition of the good (*du bien*), *how for goodness' sake should one eat well (bien manger)?*

(Derrida, 1991, p. 115, emphasis in original)

In this section, I draw on Derrida's comments, above, to consider how seed banking may be done well. Specifically, I consider how seed banking may be done well for food security. As before, my intentions for this investigation are twofold. First, the section completes my stated aim for this chapter, that of examination of three versions of seed politics. Second, this section builds upon the calls for attention to materiality in seed politics made in the previous two sections. I use this section to consider what happens when the consequences of that claim of materiality's importance to politics is applied to future practice. In other words, having argued in the previous two sections that seed politics is an outcome of the work of human and nonhuman actors, in this section I seek to

build upon that argument by applying its consequences onto the future direction of the seed banking for food security milieu. Drawing both on the work of this chapter and on the conclusions of the two chapters preceding, this final section sets out to offer suggestions on how to bank well with the intention of generating content which will usefully inform practitioners in the seed banking and plant genetic resource conservation field.

The question of how seed banking is to be done well has been discussed elsewhere in the literature, specifically in an article by van Dooren (2009). His proposal for banking seed well is one centred on what he terms the "conserv[ation of] 'biosocial' natures" (2009, p. 374). For van Dooren, as explored in Chapter 2, to bank seeds well is to bank them in a way which sees them conserved not merely in what he regards to be a utilitarian fashion, one centred on the requirements of an audience of plant breeders and researchers in the mainstream scientific milieu, but instead to bank them in a way which conserves them as materials with a social and cultural heritage. Van Dooren is critical of mainstream seed banking because, he argues, "a particular kind of nature is being imagined and produced here. More specifically, my [his] position is that these projects do not aim to conserve agricultural biodiversity at all, but rather aim to protect *and make readily available for use* a unique kind of instrumentalised genetic life" (2009, p. 375, emphasis in original).

However, where van Dooren promotes a particular version of seed banking, an Australian organisation akin to the HSL in which seeds are preserved in a biosocial manner, I follow a different approach. The approach taken in my argument for how to bank well is one guided by seed banking's role in food security. In short, for seed banking to be an effective contributor to the food security milieu, it needs to be a reliable provider of high quality plant genetic

resources for breeding and research. In other words, there must be materials must be easily and freely available in sufficient quantity, and those materials must be enmeshed appropriately within the plant genetic resources framework in the ways outlined in Chapter 5. Consequently, rather than calling for a particular version of seed banking as a means to achieve this, in this section, I propose a framework by which any version of seed banking may be regarded as banking well, but only if two universal tenets of seed banking well, critical to enabling the achievement of the requirements cited above, are followed; these are keeping options open, and assuring material mobility.

My argument is located theoretically in my interpretation of the quotation from Derrida which opens this section, and in the work of Mol. In the following paragraphs, I shall assemble this argument, drawing from each of the authors in turn. First, I consider what is meant by Derrida's call for doing something "well". In the passage, he seeks neither to formulate absolute direction on how one is to do a particular thing well, in his case eating, and nor does he seek for others to formulate that for him. In other words, he does not ask in which way one should eat. Indeed, he very explicitly states that the provision of such absolute direction is not his intention (he writes that "[t]he moral question is thus *not, nor has it ever been...*" (Derrida, 1991, p. 115, emphasis added)). Rather, his assertion is that eating in general must be done, just as I assert that seed banking in general must be done.

However, whilst one must do particular things, and do them well, the second part of my argument requires observance of the fact that there is a multiplicity to their doing well:

Like ontology, the good is inevitably multiple: there is more than one of

it. That is why for a politics-of-what the term *politics* is indeed appropriate. ... In a political cosmology 'what to do' is not given in the order of things, but needs to be established. Doing good does not follow on finding out about it, but is a matter of, indeed, doing. Of trying, tinkering, struggling, failing, and trying again.

(Mol, 2002, p. 177, emphasis in original)

My concern for multiplicity emerges also from the case studies and supporting study upon which this research is based. Over the course of this thesis I have examined seed banking at three quite different organisations. Rather than regarding one to be preferable to the others, I have found them to undertake different and equally necessary roles within the range of seed banking practice.

Consequently, by compounding the assertions of the two theorists, a point is arrived at where things must be done well, but, also, that "the good is inevitably multiple" (2002, p. 177). In other words, there is more than one overall direction to follow to conserve plant genetic resources well for food security and, furthermore, there can be no end point at which seed banking regime may be said conclusively to be being done well. The changing demands put on seed banking from user groups, coupled with the changing technical and social relations within which seed banking is embedded, mean a state of banking well cannot be perfectly and finally achieved. Rather, as Mol puts it, it is something always on the way to becoming, the work of ongoing practice (2002, p. 177). However, while this does not mean that all seed banking is inevitably seed banking done well, it does mean that all seed banking has the capacity to be so. It is with this underpinning that I base the two key tranches of my framework for doing seed banking for food security well, those of keeping options open and assuring material mobility. Before examining their justification

and their underpinning materially and in practice, which I do in the paragraphs below, I shall briefly outline what I mean by each of the tranches of this proposed framework.

Seed banking, as argued in Chapter 6, is a practice which rolls past and future into one another through practices in the present. As such, it is, following the first of the two tranches, a practice which seeks to ensure, by the preservation of all seed materials currently extant, that that which is possible now using plant genetic resources will continue to be possible in the future. Because futures are uncertain, and the food security needs unknown, it is impossible to make a judgement call about what is best saved and what may be discarded. So, it should be as possible a century from now as it is today to grow a crop of a certain amateur vegetable, or breed a specific trait out from a particular heritage variety and into a commercial one. Additionally, by preserving the materials of the past and present, the practice of seed banking implicitly envisages how the role to be played by technological advance, for example in the field of genomics, may lead to additional techniques and practices for the utilisation of banked material becoming possible. So, by banking seed, options which are hypothetical in the present because the technology is not yet available, will not become closed in the future because, in spite of the technological development, the material necessary has ceased to be available. As such, any version of seed banking undertaken must be done in such a way that it maintains this openness of options. In no way should seed banking limit or reduce that which is possible in the future in comparison to that which is possible in the present.

To bank seed well, as per the second tranche, is to assure material mobility. As I argued in Chapter 5, it is the practices that constitute the act of preserving

materials which leads them to become something called plant genetic resources. In other words, the materials of seed banking only become plant genetic resources because of the work done to those materials. As such, the materials that seed banks contain are only plant genetic resources because they are practiced into being a resource. As such, in order to maintain the resource status of those materials, merely doing the work of the first half of that double moment, that of keeping them secure in cold storage, is inadequate. To be a useful resource, it must be assured that banked materials are permitted to move about, in other words they must be made available, now and in the future, to food security practitioners such as growers, researchers and breeders.

Keeping options open

The measure of whether seed banking practice is successfully keeping options open is found in the question of whether it will continue to be possible to do in the future what it is possible to do in the present. Materially, this is engendered by two key practices: the retention of plant genetic resource materials and the information within which they are enmeshed, and the continual accrual of new materials such as those produced experimentally or those which are crop wild relatives or farmer varieties new to the plant genetic resources milieu.

Keeping options open by the retention of existing plant materials is achieved in practice through the work of sample regeneration. Specifically, it is an outcome of regenerating in a way which maintains the integrity of the sample. Thus, if a variety exhibited certain characteristics in one generation, those characteristics should remain visible in the next. For grain varieties this is usually relatively easy to ensure, because, being self pollinating, each seed is genetically almost identical to every other. The example explored in Chapter 5 demonstrates this.

When bulking out old grain varieties whose seed viability was low, Sayers was satisfied that a satisfactory new sample could be created with as few as one seed from the previous cohort. However, in open pollinated varieties, as older vegetable varieties tend to be, this aim of keeping options open by maintaining their genetic integrity is more complex. In self pollinated varieties, each seed represents all the genetic diversity associated with that variety. In open pollinated varieties, this genetic diversity is spread across the population as a whole. Individual plants are not themselves representative exemplars of the variety's entirety, and consequently one seed cannot represent all the variation within that variety. Preserving that genetic diversity thus requires care be taken in the material practices used to capture it. Work must be done when banking to ensure, first, that the sample size banked is large enough that it broadly surveys the genetic and phenotypic variation the population encompasses. Second, care must be taken when replenishing the stock of that variety that the aforementioned variation is carried forward into the next generation. The regeneration practices undertaken by the HSL, also described in Chapter 5, which seek principally to avoid genetic drift are demonstrative of such work.

The other key material practices of keeping options open do not require such technical examination. The retention and accrual of information entails simply the continuation of the practices of information management and storage described in Chapter 5. Likewise, the gaining of new material requires effective sampling from their origin, such that, just as in regeneration, the sample collected is accurately representative of the variety as it was in the location in which it was found. What is key, in each of these facets of keeping options open, is that there is no degradation of either the sample or the information within which it is couched.

Assuring material mobility

CF: I sometimes say that there's an arithmetic to the politics of genetic resources, and I can tell you what your politics are if I can ask you an arithmetic question. And that is this: You have a gene bank and you provide ten samples to another gene bank, and they provide three back to you. Now here's the question. Are you down by seven or are you up by three? Did you add or did you subtract when I told you that story?

OZ: I guess if I were a gene bank I would probably add. Because I would have already had ten, and then I would have had thirteen.

CF: Yeah, genetically and in a working global system when people cooperate and share, you've just gained three, you've now got thirteen. But many gene bank directors will subtract, and they'll say, 'whoa, I got screwed. I gave him seven, and I only got three back.' And so depending on whether they add or subtract, I know everything I need to know about [their] politics.

(Fowler, interview, 8 November 2011)

As the above quotation from Fowler demonstrates, in his experience there is reticence by some seed bank curators towards the sharing of the materials they have in their collection. It is this reticence which underpins the phrasing of this second tranche of good seed banking practice. While the first tranche called for the maintaining of an existing situation, the keeping open of options, the wording in this second tranche recognises that the practice of banking well it calls for is not at present universal. As a result, it urges seed banks to assure that materials are made mobile, encouraging those who practice mobility to continue to do so, and those who do not, to begin to do so by laying out a justification of the practice grounded in seed materiality. In this section I shall show why a framework of plant genetic resource resource sharing, something

achieved by the broader work of assuring material mobility, is a framework advantageous to the banking of plant genetic resources for food security or of, in other words, banking well. As I did above, I shall explore this argument with attention to the materialities and practices of seed banking.

The sharing of seed is, in practice, one of the key interactions undertaken between a seed bank and its user groups and as a result is foundational to seed bank practice in a very functional way. For the HSL, it is integral to the seed bank's survival. The membership fees, which make up the bulk of its income, are paid by members because they entitle those members access to up to samples of up to six varieties per year. Very simply, were the seeds in this bank not mobile, were the bank not willing to distribute samples of its accessions widely, the bank would not be funded. In a different form, that kind of relationship also underpins seed banking at the JIC where seed mobility is also integral to its funding. The JIC, which had for some years been a recipient of funding distributed to it from its parent organisation, recently begun to receive its core funding directly from the Biotechnology and Biological Sciences Research Council (BBSRC). This occurred due to the organisation having been classified a National Capability, an facility of national importance, by that research council because of the important role it plays in providing the genetic materials for research and breeding in the UK and overseas. The shift of core funding was welcomed by Mike Ambrose (2013), who manages the JIC's seed banking facility, because, as well as being demonstrative of a recognition of the facility's value, the income stream is more reliable thus making forward planning easier. Though material mobility does not confer a direct financial benefit to the SSV, in this organisation too, it is critical to its running. This is because, as a facility which backs up material (on which there is further discussion below), it does not hold stocks which would be regarded as its own

in the way done by the other two seed banks. Instead, as outlined in Chapter 5, the SSV holds copies of material originating from, and offered by, the holdings of its own user groups, other seed banking organisations across the world. In short, without a widely accepted framework of material mobility, none of the seed banks used as examples in this thesis would be able to undertake the function for which it was designed, or in other words, would be able to bank well.

In the first section of this chapter, under the heading of *The materials of plant genetic resources*, I argued that the adaptations of seeds had resulted in the coming about of a set of materials whose physical make up resulted in their being suitable as vectors for the spread of plant life in the environment at large, and that those same adaptations also made them suitable for enrolment in the seed banking milieu. By producing large numbers of high quality seed, I noted that what had evolved in plants was a mechanism by which to ensure a wide distribution of possible new plants in quantities which enabled the continuation of the population in spite of the fact that each individual seed's chances of survival is relatively low. As well as demonstrating that seeds are materials suited to the plant genetic resources milieu, my argument here is that this same evidence indicates that the practice of seeds in the environment without intentional human interference is also one of material mobility. As such, for seeds, a state of mobility is normal and indeed confers benefits. Therefore, I argue there to be firm groundings in materiality which make the incorporation of the assurance of material mobility a key part of a framework of banking seed well. Just as the diffusion of seeds in the environment promotes the survival of the plant variety, allowing it, in a Darwinian sense, to pass on the traits it carries from one generation to the next, so that diffusion does similar work in a plant genetic resources setting. It does this in two ways which I shall examine

in turn, first by ensuring the very survival of each variety, but also by making it possible for each variety to pass its traits on by being used in a research and breeding context.

The work of the SSV, an international back up of banked materials in case of either catastrophic events or what, in Chapter 5, Fowler termed “the steady drip drip drip of extinction”, is demonstrative of the first part of the call for material mobility. This is because, as discussed above, the SSV's very framework relies on a version of material mobility in which seed banks chose to facilitate the movement of material from one seed bank to another. Maintaining this flow creates a conservation advantage of the type the Global Crop Diversity Trust seeks vigorously to promote. As was outlined in Chapter 6, the conservation aims of the Global Crop Diversity Trust go further than merely archiving material sent to them in the SSV. They seek, by using access to the underground archiving facility in the SSV as a prompt to encourage participation, to broaden the scope of plant genetic resource material's distribution in conventional seed banks on the surface. A precondition of accepting material to the SSV is that it must be stored in at least one surface seed bank in addition to its original home institution. This is done to ensure readily accessible back ups exists in case of the loss of individual varieties within a cohort, and to protect against wider seed bank failure, perhaps as a result of political instability (see Pearce, 2005 on the seed bank of Abu Ghraib, Iraq) or even budget cuts (such as the warning about the potential risks from cuts to Greek seed banks by Gkisakis, 2012) (removing material from the SSV itself, because of its relative isolation, is a difficult process and therefore avoided when possible). Further, while the SSV's depositor agreement signed does not allow other institutions other than the home institution to access the material stored in the SSV itself, these being stored in black box conditions, it

does obligate seed banks to make their genetic resources freely available to other institutions on request.

The second part of the call for material mobility is reflected in a reconsideration of the two case studies outlined in Chapter 6 (for details of each project, see that chapter). Here, I discussed two projects researching potential future directions for grain crops, one based in mainstream science and undertaken by a consortium of practitioners including the JIC's own research arm, the other undertaken by the ORC, and rooted in a very different philosophy of plant breeding and indeed agricultural systems at large²⁴. The two projects were united not only by an intellectual aim to investigate possible future directions for food security practice, but materially in that each was using genetic material stored by the JIC. As I noted in Chapter 6, the project undertaken by the JIC's plant research arm was a tranche of a wider series of projects which spanned organisations without a direct affiliation with the JIC's seed bank, although these organisations were also entitled to access material from the JIC if required. The ORC has no affiliation with the JIC, and indeed in comparison with most of the work underway in the plant research field's mainstream would be considered somewhat leftfield, yet it too was able to access and make use of the JIC's stocks. These are not unusual scenarios. The JIC is proud of its commitment to the mobility of its materials, having announced in its April 2012 newsletter that 2011 had been "[a]nother year of growth" in both external requests for samples and total samples distributed (Ambrose, 2012). This

²⁴ This projects are cited in order to be illustrative of the range of possibilities at large. I note this because, in his critique, van Dooren argues that seed banking brings about an "instrumentalised genetic life" (2009, p. 375) for use solely in plant breeding. My use of two examples of plant breeding to argue my point is not to suggest that plant breeding is the only use to which banked seed may be put, but because this was the best material uncovered during my research.

material mobility is, I argue, a means by which the traits of one generation come to be successful in the next, and as such echoes the effects of the mobility of materials in seed practices not explicitly mediated by people, seed practices which, in other words, take place in the environment at large.

Materiality of the politics of banking well

The final material argument which underpins the framework of banking well, rooted in keeping options open and assuring material mobility stems from the status of plant genetic resources as a renewable resource. Because they can be generated and regenerated relatively quickly, cheaply and in high quantities if necessary, the limits to plant genetic resource conservation and use are located elsewhere in the milieu, for instance in the availability of funding for seed banking organisations or research projects. As such, I argue there to be no material impediment to there being a multiplicity of versions of seed banking, or in the uses to which banked plant genetic resources are put. It is for this reason that I argue that to bank seed well, rather than following only one particular style (as called for by van Dooren, 2009), instead is open to a broad range of possibilities. Indeed, as well as being cognisant of the different versions of seed banking, such as the three versions explored in this thesis, the changeability, or multiplicity (as discussed in Chapter 5), of possibilities of seed banking must also be recognised. In their doing, new versions of seed banking might come about, old ones disappear. As Mol argues, “[d]oing good does not follow on finding out about it, but is a matter of, indeed, doing. Of trying, tinkering, struggling, failing, and trying again” (Mol, 2002, p. 177). A range of seed bank versions keeps options open by providing various niches in which different types of material are kept secure, in the way the HSL stores material that would be of little interest to the JIC, while also ensuring that material which is of broad interest is comprehensively backed up. Further, a range of

seed banking versions keeps materials mobile by providing a network between which plant genetic resource materials may be shared, and by enabling seed banks to formulate relationships to distribute seed to specific audience types, just as the JIC and HSL have done.

However, keeping options open and assuring material mobility is not engendered solely by their being a multiplicity of versions of seed banking. Each seed bank must, I argue, follow the two key tranches of the framework for seed banking well. In the case of the first, this means that seed banks should ensure that they endeavour not to lose material or information they currently hold. They should seek to back it up where possible, and should, if obligated to reduce their stock levels perhaps due to external forces such as national budget cuts, ensure their material is taken on by another organisation. In the case of the second, they should assure that their materials remain mobile, facilitating their diffusion between seed banks and, additionally, within the research and breeding sphere.

This argument for assuring material mobility is one with the potential to engender contestation. To return to the quotation from Fowler which opened this section, I argue that banking well should not be an act of accumulation. Benefits should not be achieved merely by having access to more or better resources than one's colleagues, rather plant genetic resources should be available to all freely or at negligible cost. Although this is an ethical standpoint, it is one located in an argument centred on materiality. The preservation of plant genetic resources relies upon their being widely distributed, ensuring that should unforeseen circumstances result in loss at one seed bank, back ups of the stock are held at one or more others. Further, by allowing plant genetic resources to be widely distributed, the raw materials for agricultural innovation

are available universally. This both echoes the way seed production in plants acts as a way of moving traits from one generation to the next, but also has vital food security connotations. By limiting access to plant genetic resources, one limits access to the possibility of novel alternative practices in the food system. Had, for example, the JIC not allowed the ORC access to their wheat library at a cost that was attainable to the organisation, that piece of research (discussed in the final section of Chapter 6) would have been less likely to have been carried out. Doing seed banking well for food security requires that such experimentation is possible.

Conclusion

In this chapter I have undertaken two key tasks. I have argued for the recognition of the agency of the materiality of seeds in seed banking, and I have demonstrated that this agency is of political import. In other words, within the politically charged milieu of seed banking, I have demonstrated that seeds, as well as humans, play a role in forming the contours of that milieu. To do this, I have employed three arguments or versions of material politics: one centred on the material agency in the quotidian, one attentive to the material agency during points of disruption, and one calling for the imposition of a particular framework for doing seed banking well. Seed banking is a practice undertaken with a view to bringing about food security. As such, the materiality of seeds and seed banking, and relatedly the politics that this materiality engenders, is not only a materiality and politics of seed banking, it is a materiality and politics of food security. It is this which I shall explore in this conclusion.

In this chapter, I addressed three cases of seed politics. First, I argued seeds to be agentic in the bringing about of a seed banking milieu in which seeds could be saved both for use in the recreation of whole plants, and as a source of traits

for plant breeding. This has had substantial implications for food security. In short, it has enabled plant breeding to become one of the central pillars of crop improvement, whether in measured terms of total output of harvest per unit area of land, output according to measures of efficiency which taken into account inputs such as fertilizer, or any other mode of calculation. Were seed banking not possible, perhaps because plant reproduction routinely occurred in the ways described in the section on materialities interrupted, a regime of food security which regards plant breeding that makes use of banked seed as one of its principle methods (Government Office for Science, 2011a, 2011b; Royal Society, 2009), likely only to grow in importance with the advent of new technologies, would not have formed.

In the second section of the chapter I examined a version of seed politics concerned with disruption to the quotidian, looking at the consequences thought probable in the case of a change in the legislation surrounding distribution of heritage seeds. By enabling the distribution of such seed in the commercial realm, I argued that the version of seed banking currently in place was likely to be disturbed with particular consequences for that seed banking's efficacy in conservation. Again, this is indicative of a wider food security concern. In this case, there was a risk that the wide genetic diversity supported by populations of heritage varieties could be attenuated were the commercial distribution and, more significantly, the commercial production systems that this distribution method requires, to come to dominate this area. From a food security perspective, the implications could be serious. As argued in the paragraph above, there now exists a food security milieu in which the preservation of plant genetic resources plays a central role. Disruptive events which reduce the efficacy of plant genetic resources preservation, the case example examined being just one of a multitude of possible scenarios that

could occur across seed banking's range of versions, would inevitably lead to a reduction in efficacy in that mode of doing food security. In other words, were changes in seed banking practice to occur such that the diversity of materials conserved within it was reduced, there would be less material available for use in a food security setting.

In the final section, I built on the previous two examples, both in terms of their arguments for material politics and the consequences of the cases they contain, to call for discussion of how to bank seed well – done well, in particular, in the context of food security. I put forward a framework by which to do so, arguing that good seed banking is one in which options are kept open and the mobility of materials is assured. Keeping options open confers food security benefits in the ways outlined in the paragraph above. In short, the more material available, the more likely it is that within that material will be the precise thing required in future. And assuring material mobility means that, no matter the circumstances, it will be possible for that material to be made available to whichever organisation might require it. The fact, I argued, that seeds are so easy a resource to have in abundance further justifies this call for mobility. In short, by banking well, a seed banking infrastructure is set up which will best ensure that plant genetic resources are conserved in a way most beneficial for the bringing about of future food security.

Chapter 8: Conclusion

The formulation of the research

The research presented in this thesis has been guided by efforts to investigate the central question, "In what ways does seed banking act as a tool for doing food security in practice?".

This research question was formulated at a time when, for reasons economic, environmental and technological, seed banking and food security were becoming entangled in a novel fashion. Though this was of universal applicability, for the purposes of this research, the investigation of those entanglements was predominantly focussed on the forms they took in the UK setting. First, following the substantial economic disruption in the late 2000s, trade and open markets were shown not to be the panacea to the security of UK's food supply needs (Maye & Kirwan, 2013) that they had been argued to be in previous years (Defra, 2006, p. iii); second, a broad consensus was emerging amongst UK campaigners, think tanks, advisory groups, and policy makers, that the tools of conventional agriculture in their present form could not continue to be sustained in the long term (Barling et al., 2008; Government Office for Science, 2011a; Royal Society, 2009); and, third, particularly as a consequence of advances in a breeding technique called Marker Assisted Selection (Collard et al., 2005), the potential of seed banks as viable sources of novel genetic material for the genetic improvement of food crop plants through conventional sexual reproduction (as opposed to the more costly and more contested tool of genetic modification) was becoming possible in ways which previously had been technically unfeasible. In short, a tool with the potential to

mitigate the negative effects of the first two circumstances appeared to be located in the third. As such, this research was devised with the intention of investigating that central question in a way framed by the interface of those circumstances.

In both its formulation and undertaking, the research was premised upon understandings of the concepts of food security and seed banking drawn from relevant literature. As demonstrated in Chapter 2, the food security concept has undergone a substantial transition since its inception. Its early use was in the framework of what was then termed the "world food security system" (United Nations Universal Declaration on the Eradication of Hunger and Malnutrition, cited in Shaw, 2007, p. 140). Devised in the 1970s, following a crisis in which food scarcity and associated price rises led to famine in some regions, the world food security system was one centred on the assembly of grain reserves. These reserves were to be released onto the global food market at times when demand outstripped supply and substantial price rises became a risk. Since then, the meanings mobilised by the terminology of food security have shifted significantly. *No longer is food security regarded as something with definite outcomes to be achieved by the accrual of an adequate grain stocks, for example. Instead, food security has begun to be employed as a term with more abstract dimensions; attentive to the great diversity of work that is ongoing in bringing into being and maintaining the food supply system.*

The work of the conservation of biological materials, and, in particular, seed banking, were also addressed in Chapter 2. Like food security, the concepts and practices of seed banking have altered substantially since the time of the technology's early use. It began as a means to archive the materials collected by early practitioners of research in the plant sciences, such as Nikolaj Vavilov,

who undertook research trips to areas of the world rich in crop plant biodiversity. However, while the accumulation of materials by these early seed collectors formed the basis of contemporary seed bank stocks, at the time of their collection there were few uses to which that stock could actually be put. The maturation of seed banking, which led to a greater formalisation of its practice, came with the arrival of the plant genetic resources concept in the late 1960s (Pistorius, 1997). *At that point, the collection and storage of seeds by seed banking ceased to be an act centred on accumulation, and became premised on the notion that the materials were resources which could be of use.* Thus, over time, seed banking practice developed in a way similar to other techniques of collecting and conserving biological materials underway in the research focussed biotechnology sectors (see Hayden, 2003; Parry, 2004).

Although each was developed over the course of the thesis, current knowledge of those key concepts of seed banking and food security were assembled from the literature and acted as starting points guiding my response to the question, "In what ways does seed banking act as a tool for doing food security in practice?". *Methodologically, as the question suggests, I followed an approach drawn from science studies literature (see Latour, 1987, 2005a); in particular, I was attentive to the work of seed banking and food security in order to investigate how each came about in practice.* In order to do so, a qualitative research methodology was employed, with data collected using ethnographic methods, interviews and documentary analysis; the details of which are examined in Chapter 4. I devised three subquestions whose presence acted to further guide the direction of this research. They were, first, "How do seeds become the materials of a food security agenda?"; second, "What seed temporalities are engendered by seed banking and how do they function?"; and, third, "How do seeds function as politically engaged materials?". In the

following section, I set out the my responses to those subquestions, framed around the way they answer the central research question.

Discussion of the findings

In what ways does seed banking act as a tool for doing food security in practice?

In short, seed banking is a politically framed practice which, when done well, acts as a tool for food security by ensuring the preservation of plant genetic resource materials of the past and present such that they are available, in future, for any practices of research or breeding that might be necessary to improve the food producing capacities of agricultural systems. In the remainder of this section, I unpack the key parts of that statement according to the framework of my research subquestions.

Making seeds into plant genetic resources

Beginning with the first subquestion, I contend that there is nothing intrinsic to seeds, even those which happen to be located in seed banks, which makes them function as materials of utility to the food security milieu. Drawing upon the argument that objects come into being by the work done to, with, and by them (put forward by Mol (2002) and examined in Chapter 3), in Chapter 5, I made the claim that *it is seed banking practices which act to make seeds into materials employable by seed bank users*. In other words, it is through being worked upon in the specific ways of the seed bank setting, that the seeds of food plants become the materials of food security. *Through seed bank practices, seeds become what are termed plant genetic resources.*

However, central to ascertaining the practices which transform seeds into plant genetic resources is an examination of both what the food security milieu

requires from plant genetic resources, and what other non-food security pressures are put upon the conservation of food plant genetic material. I shall address each of these ideas in turn. First, while the timeliness of this thesis hinges upon the arrival of the breeding technology of marker assisted selection (MAS), it is also necessary to note that food security driven plant genetic resource conservation preceded the arrival of that particular technology, and is almost certain to continue after its obsolescence. The key contention made in Chapter 6 (on which there will be more substantial discussion in the following subsection), is that the work of food security is work of preparing for the unpredictability of the future. Thus, while it is known that MAS is a useful technology at present, and, furthermore, that it is likely to remain so in years to come, reorienting seed banking practice such that it produces plant genetic resources in a way attentive only to the needs of MAS (which could be to the detriment of other, more generic, food security requirements) would be inadvisable to say the least.

Second, while the seeds of food plants are amassed for reasons, largely, of food security, those plant genetic resources may also be employed in other settings, and this is something about which good plant genetic resource making practice must be cognisant. For example, during my time at the JIC, staff were developing a relationship with local thatchers and the then newly formed National Thatching Straw Growers Association. For this group, the move toward dwarf varieties which is credited for the great increases in food output since the green revolution (Hedden, 2003), had eradicated the raw material required for their trade. As such, the JIC was growing out samples from their collections of long stemmed heritage wheat varieties in order that those running thatching businesses could identify varieties which would be useful for their work (Research Diary, 9 February 2011; 16 February 2011). Thus, while seed

banking practice is focussed on making seeds into plant genetic resources for food security, they are required to do so in two ways. First, they must be cognisant of, and work towards, the unknown nature of food security requirements, rather than moulding their plant genetic resource making technique to the particular technologies of the moment; and, second, must be aware of the importance of a seed banking practice which keeps in mind the supplementary uses to which conserved plant genetic resources may be put.

Through my fieldwork, I identified three key practices which act to make seeds into plant genetic resources, and in so doing, make them into the materials of the food security agenda. These were, inclusion within a seed banking regime; replenishment of seed bank stock by regeneration; and, the accrual of an informational backcloth within which accessions are couched. Being practices, each engaged materially with the accessions; this tended to occur by their growing out into plants, for instance, to harvest a new generation of seed materials for the seed bank, or in order that the plants might be categorised or studied in order to gain new information on a particular variety. However, while engagement with the material was found to be necessary in the making of plant genetic resources, there was no requirement for the material to be physically changed or transformed. In other words, *although the purpose of this section is to demonstrate there to be a difference between seeds in general and plant genetic resources, that difference comes about as a consequence of practices and not material change.* Indeed, quite the opposite was found to be true. As was made particularly clear by the work of regeneration, efforts were made to ensure material stability, such that seed bank material remained unchanged genetically between one generation and the next.

Briefly, the three plant genetic resource-making practices operated as follows.

Addressing first the incorporation of seeds into a seed banking regime, I found that each organisation studied had their own protocol by which materials could enter their library and so become classed as an accession. At the HSL, varieties had to be of interest to UK vegetable growers and be unavailable through alternative distribution channels; at the SSV, varieties had to be already backed up at a conventional seed bank as well as being stored at their home organisation in order to qualify for entry; while, at the JIC, few new accessions were deposited as a consequence of their having already assembled a comprehensive stock. Second, regeneration was found to take place at each site, replacing seeds which had either aged and thus had reduced viability, or where stock levels were reduced as a result of seeds having been issued to users. At each site, it was regarded as imperative that regeneration practice accurately replicated the material of the previous generation. At the JIC, this meant the instigation of practices which ensured almost exact genetic replication from individual samples from one generation to the next. At the HSL, however, in open pollinated varieties where genetic mixing was possible, practices aimed to ensure the transfer of genetic diversity within the population as a whole to the next generation. Third, each organisation required that samples were enmeshed in a framework of information, which they accrued through various techniques, which was central to accessions being of utility to their user groups. In my examples, I showed how a coupling in information was central to the selection of seeds by user groups, and, how an informational framework was vital to the international distribution of seeds.

While objects come into being as a consequence of the way they are practiced, this does not mean that differences in practice necessarily engender different objects. What is clear is that the practices which bring plant genetic resources into being are not identical; rather, they reference the particular requirements

of kinds of plant genetic resources required at each site. However, following Mol (2002) once again, I contend that the plant genetic resources concept is not plural, it does not exist in many different types; rather, it is multiple, that there exist different versions of the same thing which hold together in a coherent fashion. The coordination which holds plant genetic resources together coherently is demonstrated by the broad parity in practice between each seed banking organisation, and the fact that it is often (although not always) possible for accessions in one seed banking milieu to be transferred to, and successfully function within, another. Furthermore, the case examples and supporting study of this thesis have each been deliberately selected to be contrasting, and so engage with different parts of the plant genetic resources milieu. The large proportion of seed banks in the UK and globally are most similar to the JIC, which further facilitates the coordination of the object of plant genetic resources between such organisations.

Seed banking and food security temporalities

The preservation of seeds, and the work of making them available to seed bank users by practicing them into plant genetic resources, is, as noted in the previous section, an activity undertaken for reasons of food security. In Chapter 6, and in response to the second subquestion, I undertook further exploration of that food security concept. I made two central claims about its workings, claims which were underpinned by the understanding of food security as a concept intimately related to notions of temporality. First, *I argued that the process of food security enacted by seed banking is one of making preparations, of endeavouring to bring about preparedness for a future which is, by its very nature, unpredictable*; and, second, drawing upon literature surveyed in Chapter 2 (also mentioned above) and the data collected in my empirical research, *I developed the contention emerging in the literature that*

food security should be regarded, not as a state that may be arrived at, but as a process always on the way to coming into being.

I began by examining conceptually the aims for the future which seed banking for food security encapsulate. I highlighted first, the concerns voiced by practitioners of failure to prepare for the future, resulting in the total plant genetic resource stock being found to be insufficient. This could come about as a consequence of ineffective management of existing plant genetic resources reservoirs leading to material loss, or in the event that material of potential value as plant genetic resources failed to be properly incorporated into a genetic resources milieu through seed banking practice. These concerns were justified, secondly, by the recognition of what good preparation, the state of having a substantial reservoir of plant genetic resources available, is argued to make possible. Principally, banking seed ensures that a large range of single and linked genetic traits are available to plant researchers and breeders who may need to incorporate such traits into varieties to be developed in the future. The need for such reservoirs is exemplified by the realisation that this material, necessary as it is likely to be, is not stored by plant breeders themselves because their plans for the future work to time scales adopted for business planning rather than food security. Third, although those in the plant genetic resources milieu recognise the possibility that alternative sources of plant genetic diversity might become available in the future (for example, that brought about artificially through a technique called mutagenesis), the conservation of plant genetic resource material acts as a more effective tool of preparedness. This is because it rests on the preservation of that which is known to exist, rather than basing future food security needs upon that which, hypothetically, might be possible in future.

That conceptual framework is applied in practice through the preparedness work of regenerating seed bank stocks. The workings of these acts of regeneration are, I argued, demonstrative of the contention that food security is a process always on the way to becoming. This plays out in two ways. First, there is no discernible end point for the work of seed banking while it is undertaken in the present. This does not mean that seed banking will be undertaken in perpetuity because, in practice, it is almost certain that at some point in the future it will become obsolete; however, it does mean that seed banking is undertaken in a way which prepares for perpetuity. In other words, *because that point at which its obsolescence will be arrived at cannot be known, plant genetic resource preservation practice must act as though it will not arrive*. Therefore, the work of plant genetic resource preservation for food security is a continuous and ongoing process. However, second, this sense of continuousness is disrupted by the way it is required to play out in practice. Although seed banks aim to preserve materials in perpetuity, as was demonstrated in Chapter 7, they must do so in a way which engages with the materiality of those seeds: seeds are not immutable and, furthermore, for many varieties total stock levels decline over time as material is distributed to seed bank users. Thus, seed banking practice is more commonly driven by the needs of the nearer future, such as the likely requirements of their users in the coming years. This means that *the preservation of seed bank material for perpetuity takes place in practice as a series of steps from one generation to the next*. Recognition of this is important, because it is in the process of regeneration that plant genetic resources are at their most vulnerable, where there is a risk of genetic change or even loss of stock altogether.

Acts of preparedness also act to fold past, present and future together. Seed banking is preservation of materials in the past, by practices in the present, in

order that those materials may be employed in the future. In the final section of Chapter 6, I demonstrated the consequences of this by looking at two outcomes of seed banking practice, which I argued to be the futures of seed banking past. I showed that the preservation of plant genetic resources made possible their utilisation in two quite different circumstances. Although each of the pieces of experimental work illustrated were ones undertaken with a view to bringing about food security, each were representative of very different way of doing so. As such, my argument was that the preparedness brought about by plant genetic resource preservation was one in which a diverse range of futures had the potential to be brought into being. Seed banking done effectively was argued to be done by preparing for the unknowable nature of the future by keeping options open.

Seeds as political materials

I turn, now, to the final subquestion. In being attentive to the materiality of seed banking for food security, this thesis is also attentive to the effect that materiality has on the world at large; an effect which is examined through the mechanism of politics. Indeed, I do so because I concur with the argument that failing to engage with the political in research which examines the material is to undertake only a "shallow engagement" with that material, producing work with an interest merely in the "surface" of its subject matter (Tolia-Kelly, 2012, p. 1). As such, though emerging throughout the thesis, it became the focus of Chapter 7 where I examined the way seeds function as materials engaged with politics.

My argument followed a layered approach. To underpin the investigation of the political action of materials, I began by demonstrating that seeds are agentic materials in a broader sense, examining their agency in the formation and

workings of the seed banking milieu. Plants have evolved to produce seeds which maintain their viability for a longer time by reducing their rate of metabolism when in conditions of reduced temperature and moisture levels. Furthermore, plant reproductive mechanisms and their expression in seeds is what enables the reliable preservation of genetic traits by the storage of seeds. While sexual reproduction encourages genetic difference, the number of changes between one generation and the next is usually small, and can be reduced still further through management practice. Hence, although the genetic make up of a seed that is to be put in a seed bank can only be known by growing the seed out, and hence destroying the sample, it is possible to have a high degree of confidence as to the genetic make up of a sample based solely on the knowledge one has of the parent generation. In other words, *the characteristics which make seeds effective vehicles for plant reproduction in settings which humans do not seek to influence are the same characteristics which made the framework of ex situ plant genetic resources preservation possible* (the debate between *in situ* and *ex situ* plant genetic resources preservation having been examined in Chapter 2).

And it is through the disruption of these materialities that seed agency in the formation of the plant genetic resources milieu becomes most clear. Some seeds, termed recalcitrant seeds (see also Berjak & Pammenter, 2008; Roberts, 1973), do not function in the same ways as so called orthodox seeds, like those described in the paragraph above. This may occur in two ways. First, they may fail to tolerate the desiccation necessary for freezing seeds, without which moisture in the cells would freeze and form ice crystals which damage the cell structure; or, second, they may have a tendency towards "extreme heterozygosity" (Pollan, 2002, p. 11), where substantial genetic mixing occurs between generations and, as such, the genetic make up of the offspring is

almost completely unpredictable. It is for this reason that I argue orthodox seeds to be agentic in the formation of the contours of conventional plant genetic resources preservation.

In the light of that general assertion, the second section of the chapter investigated the working of seed agency in the case of a disruptive political event. Legislation prohibiting the sale of heritage seeds, introduced several decades ago as the unintended consequence of a measure intended to protect commercial farmers, was to be modified such that their sale would once again be permitted. However, ironically, the act of making heritage seeds more widely available was predicted to have a deleterious impact on their conservation. The interface of heritage seed materialities and the old legislative framework had led to the formation of a banking system, the HSL, and a number of informal seed exchange networks in which the work of human and nonhuman agency resulted in the effective conservation of a great breadth of genetic diversity. By incorporating heritage seeds into the new legislative framework, the banking and exchange mechanisms risked being replaced by commercial exchange, which would be articulated through the management systems required by the new legislation. These management systems would act to disrupt the agency effected by seeds over their genetic make up, instead requiring it to be regulated according to the rules surrounding commercial exchange. The outcome hypothesised was an overall reduction in the genetic diversity preserved.

Given, therefore, that seeds may act as political agents, and that seed banking and food security are both concepts with the potential to be politically contentious, the final section of the chapter explored the idea of how to do seed banking well. Drawing on theory of politics in practice (Law & Mol, 2008b)

examined in Chapter 3, and recognising the variation in seed banking techniques examined over the course of the thesis, it was argued that efforts to bank seeds well should not be directed at promoting one specific version of seed banking. Rather, the existence of multiple versions of seed banking (in the manner of Mol, 2002), each of which respond to the requirements of different user groups, is neither good nor bad. *All that must be at the centre of banking seeds well, I argued, is a banking technique which best enables their preservation.* This in turn means employing banking practices that recognise and work with the material agency of seeds, two of which were examined.

First, seed banking should be undertaken in a way which keeps options open. In other words, there should be no reduction in the possible uses to which plant genetic resources can be put to in the future in comparison with what is possible in the present. Thus, the genetic resources themselves must be adequately maintained such that there is as little decline in genetic diversity as possible, and the information within which they are couched must also be retained and added to when possible. This is achieved materially through good banking and regeneration practice. Second, seed banking practice must ensure that materials remain mobile. In environments free of human interference, a wide distribution is beneficial; it ensures survival of the variety in cases of localised destruction, and it promotes genetic change by exposing the variety to different environments. These material effects should be emulated in plant genetic resource preservation. Preserving a variety in a number of locations protects against the risk of seed bank failure, and also ensures that stocks are widely available for breeding and experimentation in a diverse range of settings.

Contributions to the literature

As I set out in Chapter 1, the aim of this thesis was to make three key interventions into the literature at large. I stated that I sought

- to “provide new analytical and empirical insights into the practice of banking biological materials, specifically the seeds of food plants”;
- to “add nuance to the argument, voiced in policy and scientific literature, that seed banking may act as a useful tool in bringing about food security”;
- and, to “add weight to the claim that scholarly projects within the food and agriculture milieu are productively advanced by their undertaking within a theoretical framework centred on actor-network approaches”.

In this section, I address each of those intentions in turn, and set out how they were achieved.

New analytical and empirical insights into biological material banking

This thesis took as its starting point the framework of preexisting work in comparable areas of scholarship in the social sciences. In particular, it drew upon work examining the collection and storage of samples of biological materials by organisations searching for drugs or other bioactive compounds (Hayden, 2003; Parry, 2004). It also drew upon research considering the banking and utilisation of food plant genetic diversity, a research strand largely focussed on the heritage varieties milieu (van Dooren, 2009; Phillips, 2005, 2008). However, because of the original conceptual angles followed, and their development in different empirical circumstances, the research presented in this thesis advances knowledge in ways useful to both these areas.

In the studies by Parry and Hayden, the scientific practices examined were those undertaken with specimens of biological materials, often samples of growing plant biomass or extracts of substances from such biomass. *By comparison, in this thesis, I have examined the processes of biological material collection and storage within a materially very different frame of reference, that of seeds.* Such a focus requires attention to a different set of collection and storage practices, and a series of different fieldwork settings. Central to this new empirical insight was the examination of the practices by which the biological samples of this study come into being. I argued that it was through the work of making seeds in plant genetic resources that this took place. Furthermore, in comparison to the materials examined in the studies of Parry and Hayden, my empirical work served to demonstrate that incorporation into a biological material into a preservation setting did not necessarily require the physical transformation of that material. Instead, as was revealed in this thesis, biological material may be made into a plant genetic resource simply as a consequence of practices undertaken with and around that material, such as the accumulation of an associated knowledge base. Indeed, practices which led to the alteration of that material were almost always carefully avoided.

In comparison to other social science scholarship, in which analysis of food plant seed banking has tended to focus solely on the heritage varieties sector, this study has examined the breadth of the plant genetic resources preservation milieu. Indeed, as is demonstrated by the selection of the case studies and supporting study, and by my political commitment to multiplicity in seed banking, that broadness of investigation was a key intention of the thesis. *The aim in doing so was to argue that, rather than regarding there to be a fundamental difference between seed banking types (a contention which, elsewhere in the literature, tends to be associated with an implied criticism of*

mainstream conventional agriculture), the practice of seed banking is one which should be understood to have a universal set of attributes which undergo a degree of modification depending on the specificities of the setting.

The consequence of this is important. By denying the contention that there are fundamental differences between seed banking types, the argument that once source of plant genetic resources is better, or of greater importance, than another is also elided. This has important connotations in a time when financial resources are stretched, and at a time when there appears to be a schism between the supporters of an increasingly biotechnology centred food system and an organic, biotechnology free food system²⁵. To take a hypothetical example, in the cases of the HSL and JIC, a conviction of a fundamental difference in seed bank types could permit the argument that the kind of material of one seed bank is more preferable (according to the opinions of the commentator) the other. Instead, the recognition of the universality of seed banking allows both, indeed all seed banks, to be cast as useful sources of genetic variation. Indeed, while at present each seed banking regime tends to predominantly serve one particular type of user group, in most scenarios, plant genetic resources themselves may migrate between seed bank settings. As such, I employed the theoretical argument that the seed banking milieu as a whole should be understood as multiple, as "more than one – but less than many" (Mol, 2002, p. 55), and not as a plurality of organisations, similar but distinct.

Additionally, unlike other work in this area, this analysis of the banking of

25 For example, when the United States Department of Agriculture published a report, entitled *The Unexplored Potential of Organic-Biotech Production* (Barmore, 2009), such was the pressure from supporters of organic food systems the Department was forced to take the report down (von Mogel, 2009).

biological materials is framed by the concept of food security, to which I shall turn in the following section.

Seed banking and food security

The notion that the products of seed banking practice might assist in enhancing future food security is not in itself novel. Indeed, it is a claim widely made, ranging from the scientific advice recently given to the UK government (Royal Society, 2009) to the writing of scientists campaigning for plant genetic resource preservation over two decades ago (Fowler & Mooney, 1990). The contribution made by this thesis, therefore, is one of adding nuance to the understanding of this assertion by its consideration from a social sciences angle. *Although, in this thesis, reference has been made to the role the products of seed banking might play in food security (in particular, through discussion of banked seed in the work of MAS in Chapter 1); in fact, my broader interest has been in the way food security outcomes are brought into being by the practice of seed banking.* This is because, while the predicted role of seeds and the traits they convey in future food security scenarios have been relatively widely discussed, the consequences of the practices underway in seed banking facilities which make those seeds and genes available have received less attention.

The examination of seed banking practice has made two key contributions to the literature in this area. First, it has investigated the how the future presence of plant genetic resources comes about by examining the work that goes into their making. That, in future, there will be a reservoir of traits available for use in food security settings must be understood as being a consequence of the seed banking practices underway in the past and present. In other words, were seeds not made into plant genetic resources – were they not stored in seed

banks, regenerated when necessary, and couched in a layer of information – their genetic material would not exist for employment in future food security scenarios. *Therefore, this thesis has argued that temporality is an integral element to the functioning of food security in seed banking practice.* By preserving seeds of the past through seed banking activities in the present in order that they be made available in the future, the practice of seed banking acts to fold past and future together by work in the present.

Second, through the consideration of seed banking practice, *the work of this thesis has contributed to the argument that food security is not a state which can be achieved, but rather is a process always on the way to becoming.* The work of plant genetic resource preservation does not cease once those materials have been accumulated. Instead, the preservation of plant genetic resources is a practice which entails continuous work, finding new seed, regenerating old seed and accruing new or more detailed information.

Furthermore, this is indicative of a very different style of food security making than was found in the old “world food security system” (see Shaw, 2007) and its offshoots. Today, the notion of food security cannot be summed up as simply having food; rather, I argue it to be a concept which references the wider necessity, and ability, to make interventions in into the food system, such as having the material necessary for plant research and breeding well into the future. In other words, because the world is an inherently dynamic and unstable place, food security as a process is one attentive to the continual work of endeavouring to retain food production capabilities in spite of that instability.

Researching food and agriculture within an actor-network framework

The research of this thesis contributes to a body of literature in which actor-network approaches are employed in the studying of food and agriculture (see

the call made in Goodman, 1999). Such an approach has had three profound and interrelated impacts on the arguments made in this thesis. First, methodologically, the thesis has been centred on a way of investigating in which prioritises research into the unfolding of events. In other words, the fieldwork was centred on examining practices and employed, where possible, tools drawn from ethnomethodologies. Also, drawing from the same framework, the ways of understanding the world central to this thesis are ones based not on seeking to "know" it in a conventional sense, but instead on seeking to engage with the complexities of its "mess" (Law, 2004).

Second, through working within the actor-network framework, this thesis has made materiality central to its analysis of plant genetic resource preservation. Furthermore, in being attentive to the workings of that materiality, it has been attentive to the agency that the materiality confers. *Thus, in addition to showing how plant genetic resource materials are practiced into being, the research presented in this thesis has shown plant genetic resources themselves to have played a role in the formulation of their preservation milieu.* In other words, they are actors enacted (Law & Mol, 2008a). The mechanisms for conserving seeds in seed banks are the outcomes of the mechanisms plants have evolved to ensure the seeds they produce are most likely to grow into a new generation of plants. This agency is most evident when seeds which do function within seed banking regimes, termed orthodox seeds, are compared to those which do not, termed recalcitrant seeds.

Finally, that attention to agency by the actor-network framework has also allowed me to make a necessary contribution to the literature on the politics of plant genetic resource preservation. Where conventional interpretations of politics have tended to favour one version of seed banking over another, *I have*

put forward a political standpoint which both recognises the inevitability of multiplicity in the seed banking setting, and, in doing so, proposes a political framework for effective seed banking whose framework runs counter to the typical political intervention in this arena. To do seed banking well, I argued, is not to prioritise a particular version of seed banking above all others. Rather, it is to do it in a way which is cognisant of the agency of the materials themselves; to undertake any version of seed banking, but in a way which keeps options open and keeps materials mobile.

Wider implications

In addition to the contributions made to the specific areas of literature discussed in the previous section, this thesis has implications applicable to the wider settings of food security and plant genetic resource preservation. Having begun the thesis with a broad purview of the plant genetic resources and biobanking field, in particular by looking at the works of Parry and Hayden and by examining developments in the human tissue biobanking milieu, the purpose of this section is to return to that broader perspective in the light of the conclusions drawn in this thesis. In this section, I consider those wider implications in terms of seed banking, the food security practice it makes possible, and the seed politics which comes of it.

Seed banking practice

The thesis was centred on two case studies and one supporting study, all based Western Europe and of which two were based in the UK. The rationale supporting the selection of these specific study sites was discussed in Chapter 4. However, in selecting those sites, my aim was not to produce a series of conclusions particular to the context of those sites. In other words, while for practical reasons the fieldwork setting was European, the insights into seed

banking practice derived from that fieldwork were always intended to be broadly applicable. Indeed, it was for that reason that I selected three very different kinds of seed banking on which to focus my study. I identified three key practices underway in seed banking: the accumulation of material, the regeneration of that material, and the couching of that banked material within frameworks of knowledge and information. I argued that, although the specificities of these three practices differed between those three sites, their broad repetition across those sites was indicative of seed banking's multiplicity. In other words, rather than being a plural practice undertaken differently in different places, seed banking is one single practice which, in spite of its variations, holds together coherently. *Consequently, given my conclusions as to the centrality of these practices to the functioning of seed banking, my contention is that they are almost certainly underway, in one form or another, whether in research-led facilities, community seed banks or anything else in between irrespective of their location.* The fact that seed banking occurs in this way makes it possible for it to function as a technology which contributes to food security.

Food security implications

In Chapter 6, I made the argument that seed banking is an act of folding together past, present and future. In such folding is engendered a preparedness for future uncertainties which, consequently, shows food security not to be a state that can be brought about but a process always on the way to emerging. Central to this argument was the examination of two quite contrasting research projects which employed plant genetic resources in their research practice; one, a project seeking to isolate useful traits and create prebreeding materials for use in the conventional agricultural setting, the other, an experimental project which sought to employ a relatively untested growing

regime as a way of increasing efficiency in organic agriculture. The contrasting nature of these two research projects was argued to have been made possible by the openness incorporated in seed banking: rather than preparing for a future in which plant genetic resources are to be used in a particular way, seed banking prepares for a future in which plant genetic resources may be used in a wide variety of ways. *In this part of the section, I shall demonstrate the wider implications of seed banking's food security contribution, specifically showing that the practice of seed banking does not act as a contributor to food security solely in a Western European setting. To do so, and as a contrast to the material examined in my own fieldwork, I shall reflect on those food security implications which play out in participatory seed banking and plant breeding projects undertaken with poor farmers and located in Africa and Asia.*

Participatory methods in the food and agriculture milieu has been described in the following terms:

In contrast to the conventional methods, the new approaches to conservation and use of plant genetic resources are based on a high level of participation of farmers and their organizations at the local level. The purpose of the exercise is not a mere "physical" participation but the participatory approach aims to take comparative advantages of both scientific and indigenous knowledge systems.

(Friis-Hansen & Sthapit, 2000, p. 12)

In other words, rather than having a passive role where plant genetic resources are conserved on their behalf and plant research is undertaken elsewhere, participatory methods ensure that growers have a role in seed conservation and in the creation of the materials they are to grow.

In Ethiopia, projects have been undertaken to link subsistence farmers with the materials stored in the national seed banks of the respective countries with a view to enhancing food security. As a result of the replacement of traditional varieties with high-yielding commercial materials, those traditional varieties became increasingly less available to farmers due to declines in their personal stocks, and indeed absent from the landscape at large. Though the Ethiopian national gene bank maintains some 56,000 *ex situ* accessions, it was decided that this should be augmented by *in situ* preservation practice in order to assure the successful preservation of the diversity within those traditional varieties. (Indeed, such a practice echoes that underway at the HSL.) Farmer varieties of sorghum and elite durum wheat landrace selections were chosen to test the efficacy of this technique which sought to link conservation with utilisation (Worede, Teshome, & Tesemma, 2000).

Likewise, other projects have made use of seed bank material to disrupt the usual models of varietal provision to from mainstream breeders to small scale or subsistence farmers. In Vietnam, the national seed bank operated by Vietnam Agricultural Science and Technology Institute in Hanoi worked with farmers on a programme of participatory variety selection. Through this programme, farmers were given access to traditional varieties and landrace materials stored in the seed bank better suited to the environments and husbandry techniques available to those farmers than were the materials made available by mainstream research and breeding organisations (De, 2000). The work of improving varieties through plant breeding may also be undertaken using a participatory model. The need for such a plant breeding technique has come about following the realisation that modern elite lines, while of utility in good quality environments and in situations where farmers are able to apply

the required agrochemicals, are often less successful in marginal environments. In other words, the use of elite lines may threaten food security by reducing production volume, quality, or both.

Faced with evidence that MVs [Modern Varieties] developed for favorable production conditions have not always diffused readily into marginal environments, more and more plant breeders are searching for ways actively to involve end users in the varietal development process. The result has been a surge in interest in participatory plant breeding (PPB) methods designed to incorporate the perspective of farmers – usually by inviting farmers to participate in varietal evaluation activities, but sometimes also by teaching them formal selection techniques.

(Morris & Bellon, 2004, p. 22)

Because such participatory techniques rely on the availability of novel germplasm appropriate to the geographic milieu, where this is not available *in situ* it may be sourced from local seed banks (Sthapit & Friis-Hansen, 2000, p. 85). Though such participatory techniques are in their infancy, a future has been envisaged in which greater linkages are developed between national seed banks, plant scientists and small scale farmers (Almekinders & Elings, 2001, pp. 48–49; Thro & Spillane, 2000, pp. 48–49).

Seed politics

What is crucial to these practices and the food security possibilities they engender, is the necessity of the framework of seed politics outlined in this thesis. In other words, for such practices to come about seed banking must be done well. To keep options open materials must be preserved, and where *in situ* conservation is impractical due to other pressures on land use such as food

production, *ex situ* conservation through seed banking must be employed. What is more, materials must be kept mobile such that all those who seek to utilise it are able to. Seed banking serves as an effective way by which to do this, by acting as a hub accessible to a great number of people in a way that is more difficult for *in situ* approaches.

Having considered the wider implications of this research, in the final section of this thesis I consider how I might develop the conclusions come to in this project in future research practice.

Future directions

The arguments made in this thesis, being drawn from research centred on case studies, are inevitably “specific” (Mol, 2008, p. 10). However, that is not to say that the relevance of these assertions is specific. Rather, in undertaking this research project I have endeavoured to uncover concepts with a wider applicability; in other words, concepts which have the potential to “travel widely” (Mol, 2008, p. 110). In this section, I set out they might do so in both the non-academic and academic spheres.

There is an obligation for researchers in the social sciences to endeavour to make their research available to parties beyond the academy. That obligation is both ethically rooted and pragmatic – for example, major funding bodies such as the Economic and Social Research Council routinely require a dissemination strategy (they state that they expect “the researchers it funds will have considered the potential scientific, societal and economic impact of their research.” (ESRC, 2014)). A key feature of ensuring the concepts addressed in my research “travel widely” (Mol, 2008, p. 110) will be to make efforts to actively disseminate them into the wider debate. The mainstream press is one

route by which to do so. Prior to the completion of this thesis, I gave an in depth interview to a Canadian food journalist preparing a popular science book on seed banking scheduled for publication in late 2014. Furthermore, having had experience in preparing feature pieces for newspapers and magazines, central to my own dissemination strategy has been the preparation of articles for the mainstream press which, if not on the subject of seed banking directly, makes use of the expertise in plant genetic resources and food security that I have developed in this thesis. Midway through this project, I discussed the broader impacts of genetic engineering in a feature article hooked on a protest at Rothamsted Research. Later plans for public engagement also include the preparation of a short podcast on my research, and efforts to contribute to the wider debate on food and agriculture through groups such as Sense About Science²⁶.

Within the academic milieu, the first key site for travel is in the preexisting debate scholarly activity in the thesis' empirical milieu, which it has reopened and advanced. The core studies in the field, Parry's *Trading the Genome* (2004) and Hayden's *When Nature Goes Public* (2003) were each published around a decade ago. Through attention to different materials, seeds, and with the emergence of a new setting through which to consider the banking of biological material, that of food security, this thesis has acted to reignite interest in this area. With technological advancements making the preservation of biological material ever easier, and its utilisation ever more possible, the banking of biological resources has been shown to remain an important arena for scholarly investigation. What is more, in reigniting interest in the area, this thesis has also taken it forward. By being centred in a conceptual framework rooted in actor-network approaches, this advance has been achieved in a theoretically

²⁶ <http://www.senseaboutscience.org/>

novel fashion. The work of this thesis has demonstrated that central to the attention to the banking of biological materials must be the materials themselves. Preservation frameworks cannot be regarded as solely the products of human activity, the agency of the materials preserved is of fundamental importance to the possibility of their preservation, the practice of their preservation, and any political ramifications which may come about as a consequence of that preservation.

Second, the thesis has developed an alternative conception of the term food security centred upon understanding the way technical practices aim to bring about food system resilience. The banking of seeds does not, in itself, generate food security by causing there to be more food available (in comparison to the grain storage silos of the 1970s world food security system). Indeed, neither does preserving plant genetic resources engenders a type of food security which preempts particular types of agricultural system. What seed banking makes possible is the research into the fundamental systems of plant biology upon which agricultural systems are based, and a reservoir of traits, and combinations of traits, which may be employed in improving the plants of those agricultural systems. By banking seed, an effort is made to fortify or strengthen a food system with plant based agriculture at its centre.

The following two examples demonstrate the possibilities for future research directions. First, the preservation of genetic materials for food security purposes is not a practice which occurs only in plants; the accumulation and utilisation of farm animal genetic resources also takes place, although, no doubt, they are collected, managed and utilised in a very different fashion. The understanding of the milieu of genetic resources for food security could be productively with investigation into this area. Second, this study has highlighted

advances in the technologies which enable the utilisation of plant genetic resources. In particular, through the employment of MAS techniques, crop plant researchers and breeders have become able, for the first time, to access and make use of the materials stored in seed banks in very precise ways. It is now increasingly possible for useful traits to be isolated from banked material and transferred to commercial lines. There is, hence, also worthwhile research to be undertaken which investigates this emerging plant breeding technology

Undoubtedly, there are many other possible lines of enquiry. The travel of the concepts developed in this thesis leaves open a number of exciting avenues for future research.

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Appendix 1: Ethical research documentation

The following pages present, in their original form, the documents required for the ethical conduct of this research. The first document is an information sheet given to all research participants involved in ethnographic work, the second document is an information sheet given to all research participants involved in interviews, and the third document is a signatory sheet given to and signed by participants.

Banking seeds: the practices and politics of making food secure futures



Post-graduate research project information sheet

You have been given this information sheet because your area of expertise makes you a suitable research participant for my PhD project. I would greatly appreciate your participation in this research.

The following document provides a broad outline of the research I will be doing, your place in that research, and what you as a participant of this research can expect from me.

What is the research about?

The aim of the research is to consider how different ways of working with and storing seeds can contribute to different ways of making food security futures. The state of being food secure has been described by the UN's Food and Agriculture organisation as when "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." Though the definition of food security is relatively clear cut, there is much debate as to how it should be made to happen in the UK context. It is my contention that different seed banking techniques, like many other ways of organising food systems, can be regarded as generative processes: that by doing seed banking in certain ways, different regimes of making food security happen become more or less possible. The research will incorporate a variety of different types of seed banking.

Where do you fit in?

From preliminary research already undertaken I have identified you and the organisation with which you are affiliated as a suitable participant in my research. This is because your work involves you in the kinds of debates outlined above. I would like to undertake ethnographic work, observing you and your colleagues if appropriate, while undertaking activities connected to your role within seed banking practices. Based on observations I make, I may also request that you be interviewed informally in order that I am able to obtain a closer understanding of the work you are involved in. All meetings and observational work will be undertaken at your convenience.

Your privacy will be preserved. Any data connected to you, including but not limited to recorded interviews, research diary notes, or transcripts, will be held securely and accessible only to myself and my PhD supervisors. Your consent will be sought before the publication of your

name or professional title. Any data collected may be used in the final PhD thesis and later publication.

After consenting and at any time during the research process you will have the right to withdraw your participation. Should you choose to do so, any data collected with reference to you will be destroyed, however I do reserve the right to use data connected to you which is freely available in the public domain. The final date at which you can choose to withdraw your consent and have your data destroyed is 31 August 2011.

What can you expect from me?

I will be professional and respect your wishes at all times during this research.

If have any questions or are uncomfortable with anything that is happening connected to the research process, you should feel confident raising it with me if you wish.

I can be contacted using the following details:

Olly Zanetti
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Milton Keynes MK7 6AA

o.v.zanetti@open.ac.uk

If you wish to speak with someone else regarding this research, you may contact either of my academic supervisors:

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Banking seeds: the practices and politics of making food secure futures



Post-graduate research project information sheet

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Where do you fit in?

From preliminary research already undertaken I have identified you and the organisation with which you are affiliated as a suitable participant in my research. This is because your work involves you in the kinds of debates outlined above. I would like to undertake a semi-structured but relatively informal interview with you in order that I am able to obtain a closer understanding of the work that you and your organisation are involved in. The interview will be recorded and transcribed. All meetings and observational work will be undertaken at your convenience.

Your privacy will be preserved. Any data connected to you, including but not limited to recorded interviews, research diary notes, or transcripts, will be held securely and accessible only to myself and my PhD supervisors. Your consent will be sought before the publication of your name or professional title. Any data collected may be used in the final PhD thesis and later publication.

After consenting and at any time during the research process you will have the right to withdraw your participation. Should you choose to do so, any data collected with reference to you will be destroyed, however I do reserve the right to use data connected to you which is freely available in the public domain. The final date at which you can choose to withdraw your consent and have your data destroyed is 31 August 2011.

What can you expect from me?

I will be professional and respect your wishes at all times during this research.

If have any questions or are uncomfortable with anything that is happening connected to the research process, you should feel confident raising it with me if you wish.

I can be contacted using the following details:

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If you wish to speak with someone else regarding this research, you may contact either of my academic supervisors:

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Banking seeds: the practices and politics of making food secure futures



PhD research project agreement to participate

I, _____, (please print name)
agree to take part in this research project and give consent for any information I
provide to be used for research purposes, including publication.

The project and its purposes have been explained to me.

I agree that for purposes of the research, the PhD thesis and any further academic
publication in relation to this PhD project, I authorise my name and professional title to
be published (please circle as appropriate):

Yes, I consent

No, I do not consent

I understand that if I wish to withdraw from the project, I can do so at any time and
information connected to me will be destroyed. The final date up to which data
destruction at my request will be honoured is 31 August 2012.

If I request so to the researcher, any data that I have provided will be destroyed and
that there will be no resultant adverse consequences. However, I understand that the
researcher reserves the right to use any information about my involvement with modes
of seed banking that is freely available in the public domain.

I understand that if at any time I have any concerns about the research I can contact:

Olly Zanetti
The Open University
Faculty of Social Science
Geography Department
Milton Keynes MK7 6AA
UNITED KINGDOM

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Or, should I wish to speak with someone else regarding this research, I may contact either of the researcher's supervisors:

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Signed _____ Date _____

Appendix 2: Interview schedule details

Using interviews to study the SSV

Outline of interview schedule used with participants from the SSV.

Cary Fowler:

- Background to his current roles and standing within the various organisations he is affiliated with, what does he do day to day;
- His role as a spokesperson for seed banking and plant genetic resources;
- The role of seed banking organisations in the promotion of banked seed utilisation;
- The function of the Global Crop Diversity Trust, its role initially in plant genetic resource preservation and later in the development of the SSV;
- The political means employed to encourage organisations to make use of the SSV, and the broader legislative landscape in which it operates; and
- The technology and practicalities of plant genetic resources preservation, both generally and then specifically in the context of the SSV paying particular attention to the notion of material backups.

Simon Jeppson:

- An outline of the process which leads from seeds being assembled for storage in the SSV by external organisations, through the practices which are undertaken at the SSV, to the way which depositor organisations would be returned their material (this was discussed in fine

detail and took up much of the interview); and,

- The documentary landscape in which seeds are stored at the SSV.

Using interviews to support research at the HSL

Outline of the interview schedule used with seed guardians at the HSL.

Interview 1 – Spring:

- The reasons for becoming a seed guardian and for taking on a closer involvement with the HSL;
- Wider feelings about food systems or agriculture which informed the above;
- Being a seed guardian in practice, selecting varieties to grow, knowledge about vegetable growing; and,
- Engaging with the HSL as a seed guardian, the administering seed guardianship.

Interview 2 – Autumn:

- A narrative of this season's growing experience from planting through to harvesting (this was discussed in fine detail and took up much of the interview); and,
- Reflections on informational material given by HSL and the information the seed guardian then returned to HSL.

Using interview to broaden the study

Outline of the interview schedule employed in additional interviews not directly tied to a seed bank case study.

- Biographic information on interview participant(s);
- Details on the research project undertaken, its origins and its research practice;
- Expected project outputs, the interfaces between the project at hand and other comparable research, the way the project's outputs are thought likely to translate into mainstream agricultural materials; and,
- The contribution of the project to food security, either through gains in scientific knowledge, food system developments or both.

Participants interviewed:

- Thomas Döring of the Organic Research Centre;
- Dr. Simon Griffiths and Simon Orford of the John Innes Centre's Department of Crop Genetics;
- Penny Maplestone of the British Society of Plant Breeders;
- Martin Parry of Rothamsted Research; and,
- Paul Smith of the Millennium Seed Bank.

Appendix 3: Images

The three images referenced in Chapter 5 are printed on the following pages.

Figure 1, envelopes containing seeds stored in the JIC.



Figure 2, the entrance to the SSV, typifying the dramatic photographs which often accompany media reports.



Figure 3, the filing cabinets containing the variety files at the HSL.

